The Dock and Harbour Authority

No. 292. Vol. XXV. Edited by BRYSSON CUNNINGHAM, D.Sc. B.E., F.R.S.E., M.Inst.C.E. February, 1945

CONTENTS

Editorial Comments

The Leith Breakwaters.

We are indebted to Mr. Dalgleish Easton, the Leith Docks Engineer, for permission to publish in this issue his recent extremely interesting address to the Edinburgh and District Association of the Institution of Civil Engineers, of which he is chairman, containing a very instructive account of certain experimental investigations undertaken in Holland in connection with the designing of the new breakwaters at the Port of Leith for the extension of the harbour. Our readers will find in the address much information for attentive study.

Departing radically from methods of breakwater construction hitherto prevalent in the British Isles, Mr. Easton boldly set out to construct the breakwaters with material little likely, at first sight, to commend itself as suitable to withstand the onset of rough seas. But the results obtained in the dykes and sea walls of the Netherlands demonstrated that mounds of sand and clay in bulk, properly protected by stone surface pitching could be rendered resistant to storm wave action without suffering undue or irreparable damage. Accordingly, the Leith breakwaters have been constructed on this principle, following the carrying out of experimental tests at the laboratory at Delft, which enabled the detailed arrangements of the mounds to be worked out and designed on sound lines. We had an opportunity during the course of its construction of inspecting the work, and feel entitled to congratulate Mr. Easton on a remarkable, and for this country, a novel type of maritime construction.

No doubt, in very exposed situations the use of massive blocks of stone and concrete monoliths for breakwater construction will still receive preference, but in localities where stone is scarce and sand and clay are available and can be economically dredged for the purpose, mounds of sand and clay covered by impervious pitching undoubtedly form an excellent substitute, and will probably be used to an increasing extent in the future. Everything depends, however, on maintaining the stone pitching intact ; for once the surface is disturbed or broken, the disintegration of the interior will proceed rapidly. The results of a series of winter storms on the Leith breakwaters will naturally be watched with great interest by harbour engineers, with every hope that the work will successfully withstand the ordeals to which it may be subjected.

British Port Control.

The coming month promises to be of exceptional interest to British port officials, because on the 14th there is to be held a special meeting of the Dock and Harbour Authorities' Association at which a decision is to be taken, which will be of supreme, and even vital, importance to the undertakings concerned. The Association has to consider and determine its attitude in regard to the subject of future port control in Great Britain and Northern Ireland, arising out of the invitation of the Ministry of War Transport to the Association that it should put forward its own proposals for the modification and improvement of the present regime. The matter has been under consideration for some time by a special committee of the Association, and their recommendations are, it is understood, to be laid before the meeting for discussion and approval.

Naturally, the matter has aroused widespread interest in port circles and divergent views have been expressed in various quarters, some of which have been ventilated in these columns. They range from advocacy of a complete abandonment of the present heterogeneous collection of independent authorities and their replacement by a single co-ordinated and central administration directly under the Government (scarcely distinguishable from what is called Nationalisation), to relatively minor changes, principally in the direction of the district grouping of ports, under regional or local control. Actual investigation into proposals of the latter variety is already in progress; notably in the case of the Clyde ports, for which an official committee appointed by the Ministry of War Transport is sitting under the chairmanship of Lord Cooper.

Whether it will be possible to reconcile these conflicting views and put forward for adoption a scheme generally acceptable to the members of the Association remains to be seen. We are not in a position to gauge the prevalent trend of opinion. We do feel, however, and venture to express our conviction that at so momentous a juncture in the evolution of British port administration, it is desirable to proceed with great caution. We have already indicated our view that any drastic and revolutionary upheaval is to be deprecated and that where a satisfactory degree of operational efficiency is already attained (as is admitted to be the case in the overwhelming majority of British ports) it would be unwise to disturb their present status, merely in order to introduce something new and untried.

It is an obvious fact that at the present time a large section of the public is clamouring for an immediate and fundamental revision of the present order of things and demanding the adoption of entirely new ideas in schemes, not all of which are based on

Editorial Comments—continued

sound and unchallengeable principles. In a number of instances the results of these changes are largely speculative and uncertain. To act on such premises is by no means a wise policy and we venture to commend to our readers some very prudent counsel uttered by a profound thinker and statesman of the early XVIIth Century. In his Essay " On Innovations," Francis Bacon (commonly known as Lord Bacon, though his proper title was Baron Verulam and Viscount St. Albans) wrote as follows:

" It were good, therefore, that men in their innovations would follow the example of time itself; which indeed innovateth greatly, but quietly, and by degrees scarce to be perceived. . . . . It is good also not to try experiments in States, except the necessity be urgent, or the utility evident; and well to beware that it be the reformation that draweth on the change, and not the desire of change that pretendeth the reformation; and lastly that the novelty though it be not rejected, yet be held for a suspect."

These are wise and weighty words. They should be pondered carefully at a time when the nation, weary of prolonged restraint and innumerable war-time restrictions, has become impatient with the existing arrangement of things and is contemplating changes of vast scope and far-reaching extent. They are particularly applicable to the domain of port administration in regard to which it may pertinently be asked whether the need for drastic change is really urgent or the utility clearly evident. Ports came naturally into the terms of reference of the 1928 Royal Commission on Transport, but the Commission, while indicating a preference for autonomous elective bodies, deliberately refrained from making any recommendation to effect a change in the present system of control.

It is true that defects have exhibited themselves in certain specific cases. Among the allegations put forward are the redundancy of ports in some localities, the inefficiency and poverty of a few of those of the smaller class and the overlapping of " hinterlands," with unfair and uneconomic competition among the larger ports. Against these contentions it is to be pointed out that all humanly devised systems have imperfections and that most, if not all, of the foregoing defects could be eliminated or remedied without disturbing the general framework, particularly as regards the freedom at present enjoyed by the sea-trading community to pursue their own plans and course of action. This naturally involves competition between ports, which, within reasonable limits, is a public advantage: it encourages enterprise and prevents monopoly.

It has been argued that the amalgamation of the railway systems of Great Britain into four great unitary bodies is a signal and convincing precedent for a similar centralisation of port administration. But, in our view, the analogy is imperfect and misleading. Railways and ports do not lie in the same category. The former are interconnected and interdependent, with uniform structure and common operation. The various companies have shared running powers over each other's lines. Ports, on the other hand, are separate entities, with independent interests and dissimilar methods of operation. In the past they have, as the late Sir Joseph Broodbank pointed out, preferred " like the stars to dwell apart," developing along their own lines in accordance with local views and traditions.

At this point, we must, for the present at any rate, suspend our observations. They are supplementary to those made in the issues of December and September last, to which readers can refer if they wish to do so. Port officials throughout the country look to the Dock and Harbour Authorities' Association to find a satisfactory solution to the problem.

Seaplane Bases.

Consideration has been given in this Journal on several occasions within the last year or two, to the situation which will necessarily arise after the war, when the expansion of civilian aerial travel will entail the provision of extensive accommodation at suitable points on the British coastline for seaplanes with their passengers and freight. It is, no doubt, true that hitherto the aeroplane, with an inland base, has attracted and held public attention to a much greater extent than the seaplane or the flying boat, by reason of a certain superiority in safety and convenience which the aeroplane exhibits, but apparently, there is no reason why the seaplane should not be improved so as to overcome its alleged drawbacks. Mr. Colquhoun, extracts from whose paper on " The Design and Planning of Airfields and Airports " are reproduced in this issue, speaks confidently of the ultimate popularity of the seaplane.

Accommodation at harbours sufficiently well-sheltered for the purpose and possessing convenient accessibility as regards inland transport, will, therefore, naturally become a leading concern of port authorities, if this is not already the case. Indeed, there are actual instances of seaplanes at British ports using the same channel and seaway as merchant vessels, within, of course, special demarcation limits. Such joint use may, or may not, be desirable, but it indicates the nature of the problem facing harbour authorities who cater, or wish to cater, for both services.

The seaplane has particular claims to utility and safety on long ocean journeys, and there is every reason to expect its development on a large scale in connection with the transatlantic passage. Whether, if so developed, it will ever oust the steamship and sea surface vessel from their pre-eminence on this and other similar routes, is a matter at present merely for conjecture. Probably not in entirety, but it may supplant an appreciable amount of shipping tonnage, and it will certainly constitute a new and important branch of overseas transport.

Spending Beaches.

The article on The Spending Beach by " Helios," in the current issue deals with a phase of wave action which, as yet, has not received much attention from investigators of maritime problems. The reflected wave, or *clapotis*, as it is termed on the Continent, has come in for a good deal of discussion and experiment, resulting in the enunciation of certain definite results, but the case of a wave expending its energy on the surface of a sloping beach has apparently been ignored, though it is of importance as a useful and practical means of reducing the disturbance in harbour waters of rough seas passing through a narrow entrance. Sunderland Harbour is a case in point. The waves rolling in between the pierheads, 200-ft. apart, of the outer breakwaters, are directed towards a spending beach out of direct line with the inner harbour piers, so that a considerable portion of their energy is dissipated away from the inner entrance.

The subject is one which is worthy of attentive study, since spending beaches are not without certain disadvantages. It has been pointed out that where a spending beach, only partially effective in destroying waves, is formed very near the harbour entrance, it may result in a back-wash, or recoil, detrimentally affecting the navigation of vessels.

Dundee New Dry Dock.

The project for a new dry dock at the Port of Dundee, adumbrated in our issue of November last, has now materialised to the extent that the Harbour Trust have considered and approved the plans prepared by their Engineer, Mr. Norman A. Matheson, for a dock of dimensions and arrangement explained in detail on a later page of this issue.

Of the dimensions only one seems to call for comment. The length of the dock (650 feet) is presumably the maximum consistent with the needs of the port and the accessibility of the site. The width of entrance (85 feet) is more or less conditioned by the length, to which it bears a definite ratio, as in the case of ships. The rather outstanding ratio of 1 to 7.5 has been selected, due to the modern tendency, pointed out by Dr. James McNeill, in an address reported in our December issue, to increase the beam of vessels. At one time—about a couple of decades ago—the ratio used to be ordinarily between one-ninth and one-tenth of the length of a vessel, so that the increase is rather striking. The situation is, of course, controlled by the naval architect and port authorities have to accept his technical ruling. None the less it entails additional expenditure on dry dock construction, since width of entrance must be sufficient for all likely requirements.

Despite the uncertainty regarding further developments in the size of ships, it seems likely that the dimensions chosen for the new dry dock at Dundee will prove satisfactory and enable it to function successfully for a long period to come.

The New Breakwaters at the Port of Leith

Preliminary Model Tests for Design

By J. DALGLEISH EASTON, M.Inst.C.E.*

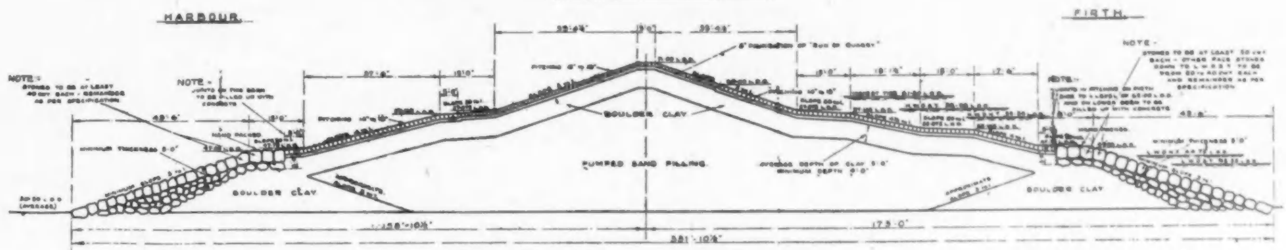


Fig. 2. Cross Section. East Breakwater

Introduction.

IT is, I think, the custom of your new Chairman to take for the subject of his opening address to the Association, the branch of Civil Engineering with which he has been associated. In my case it is the engineering connected with the construction and maintenance of harbours and docks.

By coincidence, the President-elect of our Institution for the ensuing year is Mr. Wentworth-Sheilds, the eminent Docks Engineer, and, as I have no doubt he will deal with the general question of harbour and dock construction in his Presidential address, I propose to-night to confine myself to a particular work and to tell you something about the preliminary investigations in connection with the design of the new breakwaters recently completed at the Port of Leith.

The purpose of the breakwaters was to form a new entrance to the port, farther out into the estuary, to take the place of the old entrance which was built in 1852, and at the same time to enclose a considerable area of the sea so as to provide room for future extensions to the Port of Leith. (Fig. 1 overleaf).

The breakwaters are constructed on the same principle as the great dyke formed some years ago by the Netherlands Government across the Zuyder Zee, and I think they are the first breakwaters of this type to be constructed in this country.

When investigating the methods employed at the Zuyder Zee, I, along with my colleague, Mr. Fortune, visited Holland and, when there, received the greatest of kindness and all the information we required from Mr. Van Keffeler, the engineer-in-chief of the waterways. It was then that we learned of the necessity of investigating the various problems arising in connection with the design of the works, by means of experiments on scale models carried out in a properly equipped hydraulic laboratory.

The Netherlands Government had, some years before, built such a laboratory at Delft and they kindly agreed to the experiments for the Leith Breakwaters being carried out there by Professor Thijsse, the able Director of the laboratory, and his assistants.

During several visits to Holland, we witnessed many of the tests, which extended over a considerable period and the diagrams which I propose to show you to-night are taken from those which accompanied Professor Thijsse's reports.

The experiments were divided into two main series :—

1. To find a satisfactory cross-section for the breakwater, so that it would withstand the heaviest storm possible at Leith.

2. To find the most suitable positions of the seaward ends of the two breakwaters to form a new entrance to the port and in such a position as to reduce as much as possible the disturbance of the water in the harbour during storms.

PART 1. First Series of Experiments

Each breakwater consists of a mound of pumped sand encased within a thick layer of boulder clay, the toes of the slopes being formed by two parallel mounds of tipped boulder clay, the top of which are a little above low-water level. (Fig. 2). The whole structure is formed with long flat 4 to 1 and 3 to 1 slopes with three berms where the planes of the slopes would intersect. To protect the boulder clay from the action of the waves, the whole surface of the slopes and berms above low water level is covered by a layer of heavy whinstone blocks laid on a foundation of rubble, while the tipped boulder clay mounds at the toes are protected by a tipped rubble mound with stones varying in weight up to $2\frac{1}{2}$ tons.

The principle of the design is to provide long flat slopes and berms in such a manner that they are sufficient to allow the waves to run up the slopes and so dissipate their energy, and the object of the tests is to find the slopes required and the position and number of berms to do this. The berms hold the waves and thus cause them to form a water cushion.

The maximum width of the base of the East Breakwater is 360-ft., with a maximum height of 43-ft. above the bed of the sea.

The East Breakwater is about $\frac{1}{2}$ mile long and the West Breakwater is $\frac{3}{4}$ mile long. The area enclosed is about 250 acres.

Before proceeding with the experiments, it was necessary to have some knowledge of the dimensions of the waves to be expected in the Firth of Forth and to this end we erected an observation station at the end of the old East Pier and made careful records of the waves during several storms. The Meteorological Office kindly supplied us with their records of wind velocities during these periods.

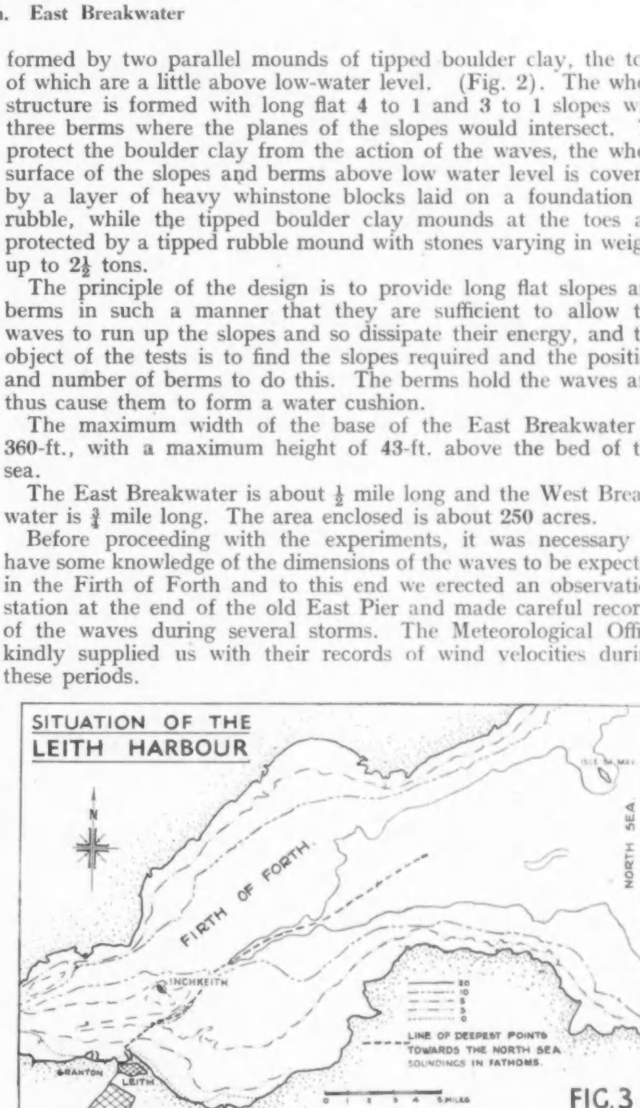
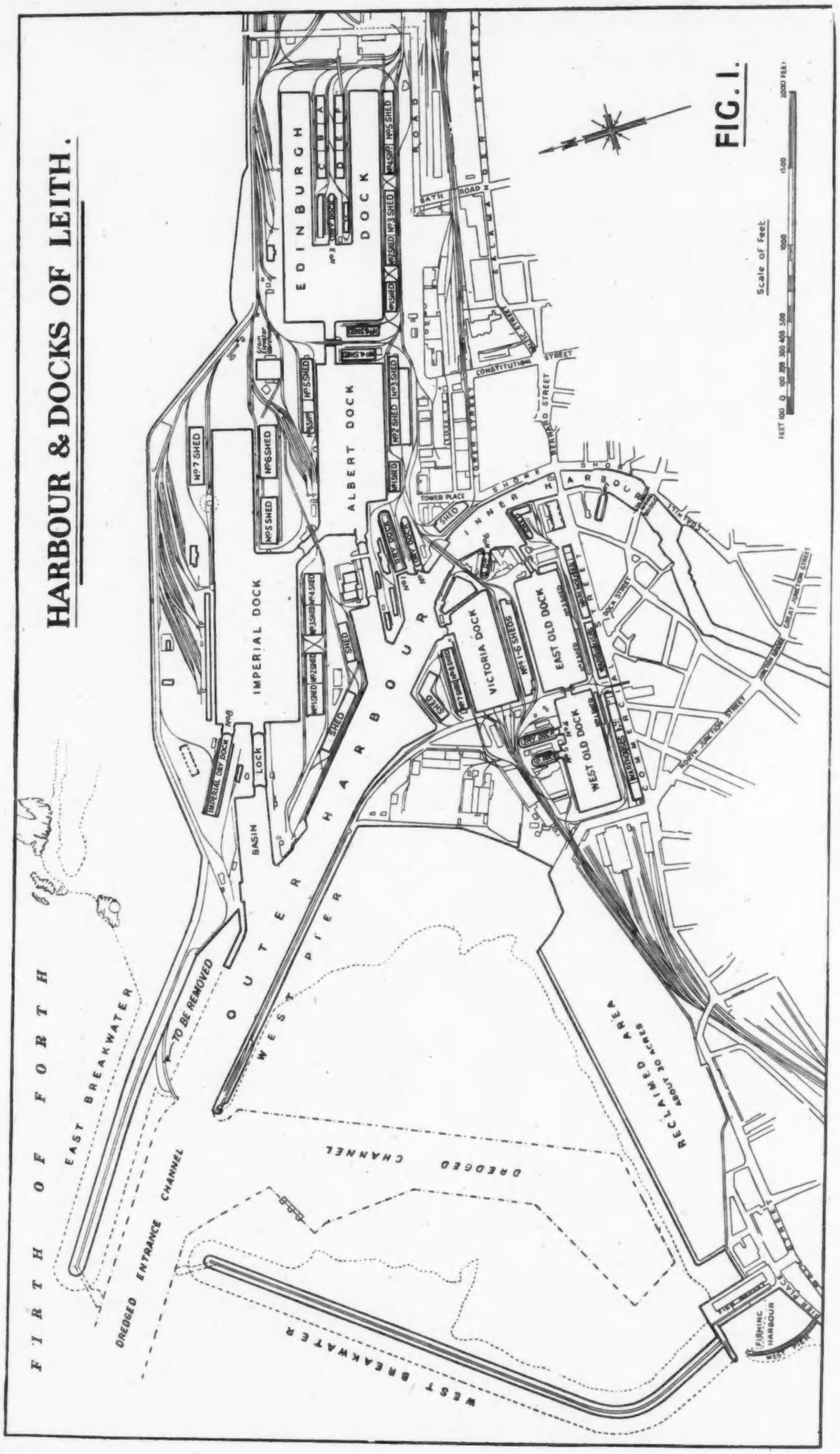


FIG. 3

This, however, was not sufficient for the purpose of the experiments, because such local observations are not sufficient unless they cover an exceedingly long period and so include the maximum waves. From records of the wind intensities and hydrographical conditions, Professor Thijsse arrived by calculation, at a sufficiently dependable estimate of the greatest possible wave attack.

*Chairman's Address to Edinburgh and District Association of the Institution of Civil Engineers, 11th October, 1944.



General Arrangement of Leith Harbour

New Breakwaters at the Port of Leith—continued

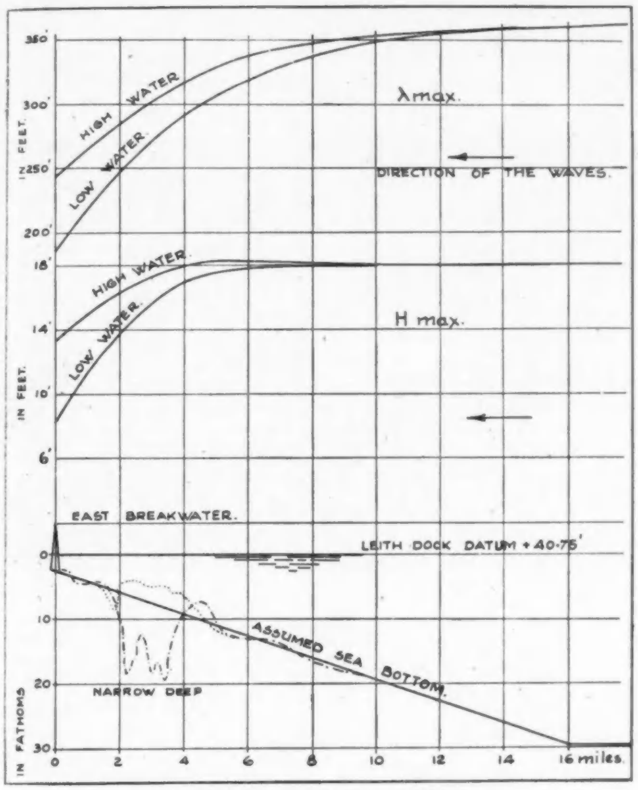


Fig. 4. Deformation of the Waves

The greatest wind velocity in the North Sea was assumed to be 60 m.p.h., which, when reduced to sea level gives 24 inches per second and, starting from this, the particulars of the wave were calculated for the place in the estuary where depth of water is so far reduced that it begins to have an influence on the propagation of the zero wave. This is at a depth of 30 fathoms and the place was found from the chart to be 16 miles from the East Breakwater, which is the one exposed to the North East and so attacked by waves from that direction which have a fetch out into the North Sea. The Zero is in the deep water East of Inchkeith, as shown in Fig. 3 with the path of the wave forward to the East Breakwater. The wave at the Zero was found to have a wave-height of 18-ft., a wave-length of 360-ft. and a period of 8½ seconds.

As the wave approaches Leith, the depth of water decreases so that the dimension of the wave decreases. This is shown in Fig. 4, where we have an approximate section of the sea bottom from Zero to the breakwater, with a graph showing the maximum height and length of the waves as they approach both at High Tide and Low Tide.

At the breakwater, the maximum wave-height is 13½-ft. at High Tide and 8½-ft. at Low Tide, and the maximum wave-length is 245-ft. at High Tide and 185-ft. at Low Tide, the period in all cases being 8½ seconds.

The calculations were checked by the observations made at Leith and it was found that the average of all the observed waves was 80 per cent. of the calculated waves and the average of the maximum observed waves was 100 per cent. This was considered satisfactory and the calculated waves were applied in all the model experiments.

Experiments to find Breakwater Profile

The experiments to find the best possible profile for the breakwaters were carried out in a covered flume 13.2-ft wide and 88-ft. long. The flume was so constructed that waves could be reproduced; a current of air blown over the water surface; and the height of the water level in the flume could be varied.

The waves were produced by means of a machine placed at one end of the flume. The wind was produced by fans in a tunnel under the flume and open to it at each end. Plan and sections of the flume are shown in Fig. 5, while Fig. 6 is a photograph taken inside the flume.

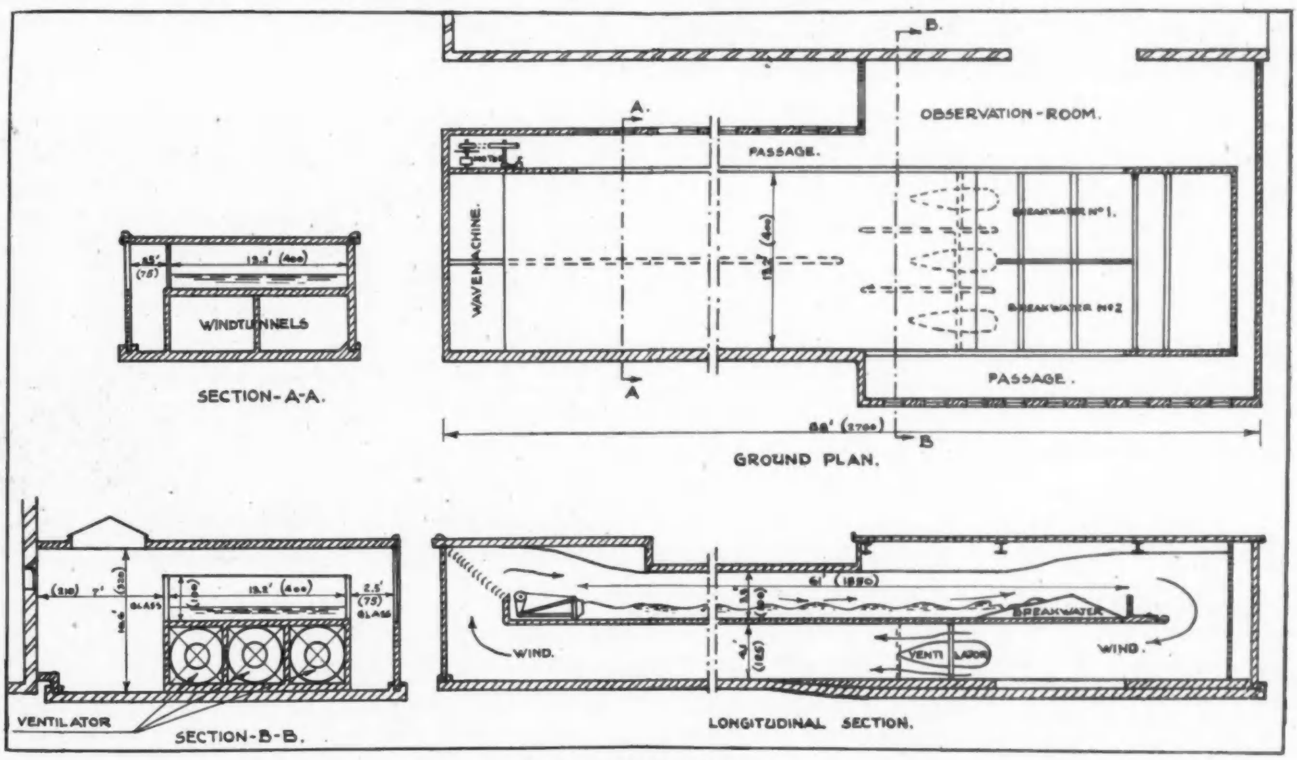


Fig. 5. Model-Installation

New Breakwaters at the Port of Leith—continued

The model under test was placed at one end of the flume where the sides were constructed of glass so that observations could be made. The scale ratio to be applied was limited by the dimensions of the flume and this worked out, for these experiments, at 1:25.

To obtain in the model experiments the movement of water similar to that in nature, it was necessary that all accelerations should be equal to those in nature. This condition allowed all other scale ratios to be derived from the scale of lengths.

A pressure of wind was expressed as the height of a column of water and so had the scale ratio of length. The scale of velocity is the square-root of the scale of length and so on.

Description of Model

In the flume two profiles of breakwaters were placed next to each other, and both examined at the same time, their widths being each 200 centimetres. (Fig. 7). They were constructed of wood and it was found that only 35 centimetres of the width of each model required to be completed with the rubble layer, the tipped stone and the stone pitching.

The layer of rubble which is 8 inches thick in nature, was made of fine stone chips 1 centimetre thick. The stone pitching which varies from 18 inches to 8 inches thick, was represented by small marble blocks having the same specific gravity as whinstone, while the tipped stone was of whinstone and carefully weighted to represent the actual blocks.

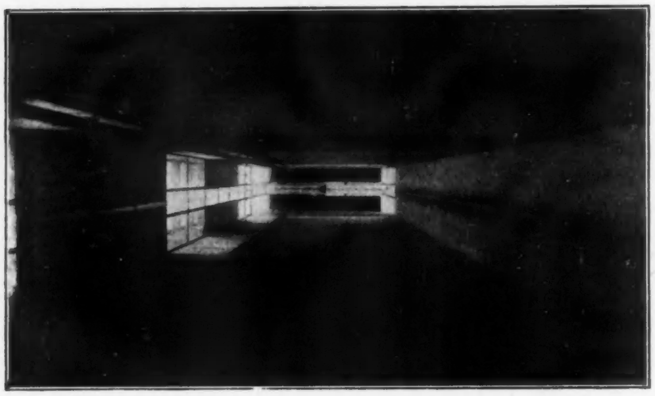


Fig. 6. The Wave-flume seen from the Wave-machine

Measurements and Method

The various quantities to be represented in the experiments were :—

1. The water depths.
2. The waves. Height, length, period and velocity.
3. The velocity of the wind.

The water depth was measured by means of gauges.

The period and velocity of the waves which are related to each other, were fixed by an apparatus as follows :—

Two bars at a distance of 2/3 of a metre from each other in the longitudinal direction were suspended from a rail attached to the ceiling of the flume and so arranged that they could be moved along the rail to enable measurements to be made at different distances from the model. The bars were adjusted so that the wave crests just touched their lower ends. Each bar was separately connected with an electrical source in such a manner that when a wave crest touched the bar the circuit was closed. In each of the two circuits a relay was introduced and connected with a pen and both pens rested on a recording drum rotating at a known constant velocity.

Each time a wave touched one of the bars the pen recorded it on the drum paper. The lengths between the points were then measured and from this and the speed of the drum, the period of the wave was found. The distances between the points marked by the two pens for the same wave crest gave the velocity and from this it is possible to find the wave length. These values were checked by means of formula.

The height of the waves from crest to trough was measured at various points along the glass windows of the flume, which was provided with horizontal lines for the purpose. (Fig. 6a).

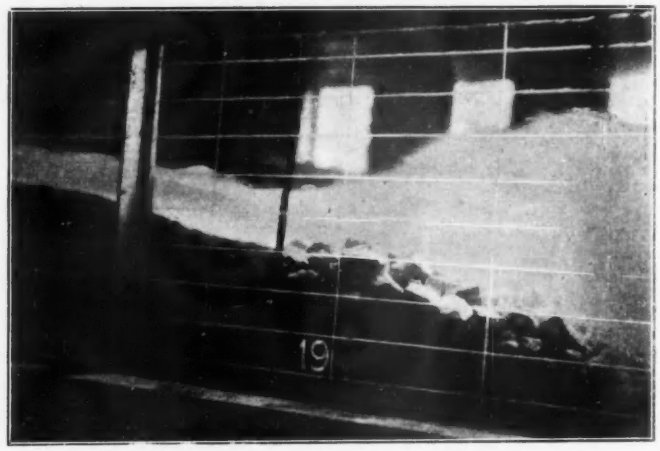


Fig. 6a. View of Flume showing Glazing

The velocity of the wind was gauged by means of three Pitot tubes arranged one above the other in such a way that they could be moved together over the width of the flume.

The water depth was regulated by filling or emptying the flume to the required depth. The period and length of the wave were adjusted by varying the number of revolutions of the wave machine motor and the wave-height by an adjustment of the eccentric of the machine.

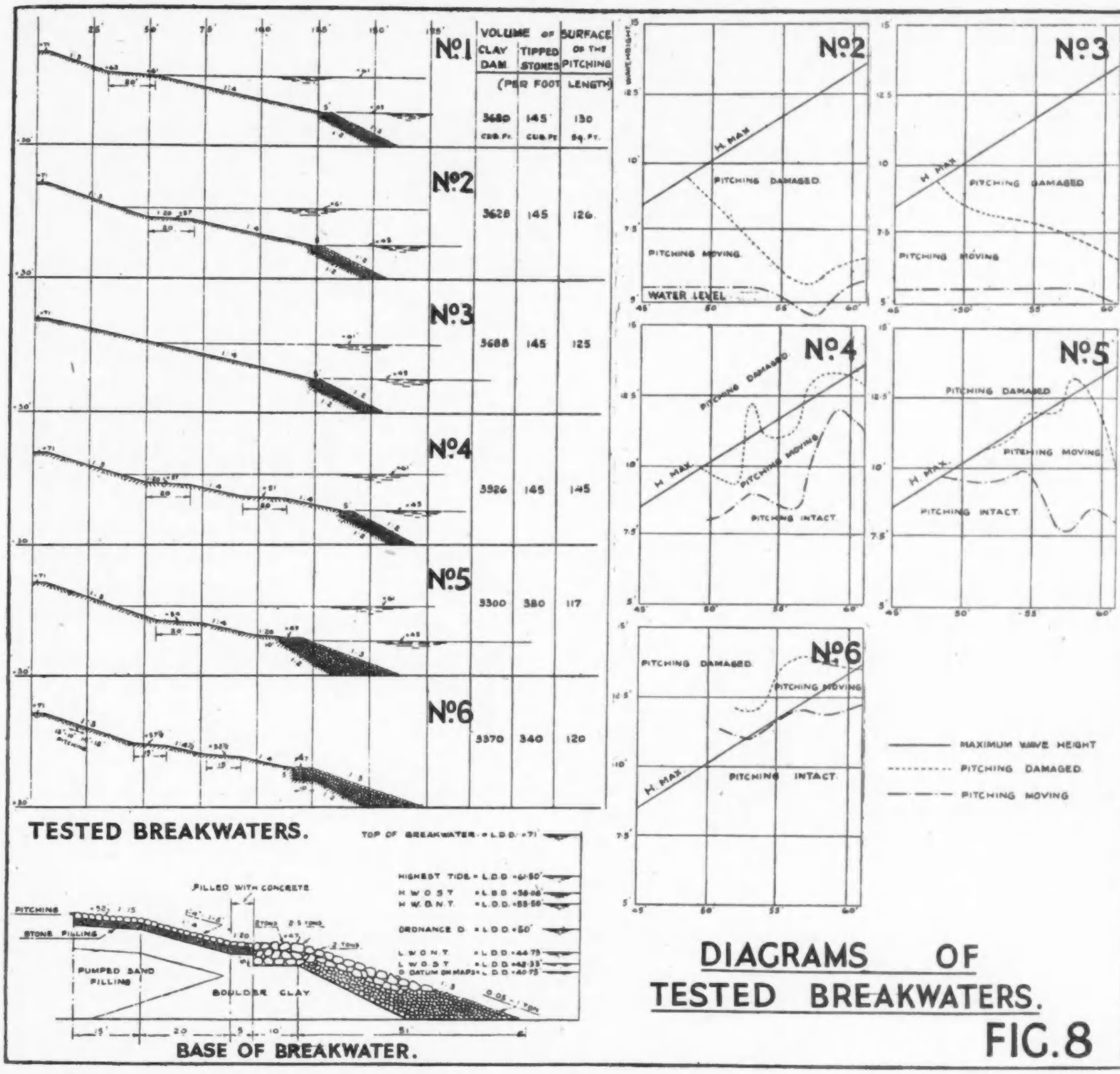
It was found advisable, before carrying out a series of tests to find the correct adjustment of the wave-machine to give the required dimensions of the wave for each water depth and prepare a gauge table. Great care had to be taken while carrying out this work to eliminate all reflection of the waves from the end of the flume. This was done by substituting for the model, while the adjustments were being gauged, a wave absorber consisting of a flat slope of wire netting.

Fig. 7. View of the Model

The desired wind velocity was adjusted by means of a Pitot tube placed at a fixed point where the velocity was characteristic of the cross-section of the flume.

By these means it is possible to secure a high degree of accuracy and certainty well within the accuracy that can be obtained when making similar measurements in nature.

New Breakwaters at the Port of Leith—continued



DIAGRAMS OF TESTED BREAKWATERS.
FIG. 8

Tests for the East Breakwater exterior profile

The following is a short description of the tests carried out to find a suitable exterior profile for the East Breakwater.

The exterior face of this breakwater is almost at right angles to the direction of approach of the maximum waves coming in from the North Sea and the maximum height of the breakwater was fixed by the Act of Parliament authorising the works.

The range of ordinary spring tides at Leith is approximately 16-ft., but it was not considered advisable to carry out the tests with a rising and falling water level, if accurate observations were to be made.

It was, therefore, decided to divide the tide range of 16-ft. into ten sections and to carry out a test for each of these with the corresponding water level, beginning at Low Water and proceeding to High Water and then back to Low Water in steps of 1.6-ft., two sets of measurements being taken for each water level. For the purpose of verification, however, measurements were several times carried out with a constantly increasing and then decreasing depth of water and it was found that the results were not less favourable.

The wave dimensions were also increased by steps for the same reason as the water depths and for each profile the test was always commenced with a wave height well below that which was likely to damage the breakwater and stepped up by stages to the maximum wave. The period for the first stage was 5½ seconds and that of the last 8½ seconds.

Determination of the resistance of the Breakwater against wave attack

As we do not know how the attack on the pitching on the face of the breakwater actually takes place or the factors which determine the force of the attack, it is not possible to arrive at a satisfactorory profile and method of construction except by process of investigation on models of various profiles and noting their behaviour under the attack of the waves.

Even with this method a difficulty is encountered, as the resistance of the stone pitching is greatly influenced by the degree

New Breakwaters at the Port of Leith—continued

of tightness between the various stones. In actual practice in a well pitched slope, the stones will be very tightly packed. but after some time they may be loosened on account of settlement or as a result of wave action.

It was found impossible to imitate satisfactorily the stone pitching in the models and it was, therefore, decided to carry out all the experiments with very loose pitching with the stones hardly supporting each other. By this means the model breakwaters were tested under the least favourable conditions, as each stone was separately attacked by movement of the water and it was, therefore, assumed that if the model had sufficient resistance, an actual breakwater would be safe under all possible circumstances.

With a certain water level the waves were regularly increased and at the same time, the behaviour of the pitching stones was carefully observed and a record kept of the wave height at which the pitching stones commenced to move and also that at which the first damage was caused.

These records were plotted on a diagram which included the maximum height of the wave which could occur at every water level. It should be noted that it is not an absolute condition of safety that the curve indicating the limit of the damage is entirely above the curve indicating the heights of the wave. Such a condition could only be satisfied at great cost and a slight damage in the model caused by the largest wave was considered allowable, as the pitching stones in the actual breakwater are much more compact than in the model.

With the tipped stones at the toes of the breakwater, the difficulty experienced with the pitching did not arise, because their actual condition could be exactly reproduced in the model. These tests also concerned the movement and washing away of the stones, so that it was a condition of safety that the berm and talus would retain their shape and that the large stones would not wash away, although a slight movement under maximum conditions would not be deemed to be prohibitive.

The visual observations of the behaviour of the pitching and toes of the various profiles tested could not, in the scientific sense, be considered "accurate measurement," as they are to a considerable extent dependent on the person who makes the observations. To get over this difficulty, arrangements were made for all the tests to be carried out by the same person, so that the manner of appreciation was the same for all the experiments. For the same reason the placing of the pitching stones on the model was always done by the same workman.

Investigation of Profiles. (Fig. 8)

No. 1. This profile has a berm 5-ft. wide at the top of the tipped stone toe and another 20-ft. wide at High Water level. Under test it soon appeared that this profile was unsatisfactory. At low tide, the smaller tipped stones moved even with small waves and at High Tide the crest of the berm was damaged, indicating that the berm was in the wrong position and did not form a water cushion of sufficient depth.

No. 2. This profile is the same as No. 1 except that the higher berm is lowered by 4-ft. and this showed an improvement at the higher levels of the breakwater, as the berm now fulfilled its purpose and caused the wave to break in a water cushion. At the lower levels the results were the same as in No. 1.

No. 3. This profile consisted of one flat slope of 1 in 4½ throughout the height of the breakwater and proved to be entirely unsatisfactory with the same sizes of pitching stones as Nos. 1 and 2. Heavier stones at the higher levels would have improved the results, but this would have added considerably to the cost of the work.

No. 4. This gave much better results than any examined before, as the resistance was increased at the higher water level. At the lower water levels, however, damage occurred, due to the fact that the berm at top of the tipped slope was too narrow to cause the wave to completely break. This caused damage to the crest of the next berm.

No. 5. The slope of the tipped toe has been flattened to 3 to 1. In this profile the berm at the top is widened to 20-ft. and raised 2-ft. One other berm was provided at a level of 7-ft. below High Water level. This profile proved satisfactory at the lower levels, but was dangerous when the tide rose above the level of the top berm, as the larger waves ran over this berm without breaking, thus damaging the pitching.

No. 6. The profile is somewhat similar to No. 4 with the improvements of a wider berm at the top of the tipped stone and the raising of this berm by 2-ft. This profile proved entirely satisfactory, although at the higher levels, the pitching moved a little, but was not damaged by the highest waves. The crests of the berms are all well protected by the lower berms.

An additional test to a larger scale was carried out for the tipped stone toes of the breakwater and these confirmed the investigations with the small scale models.

As a result of these latter tests, however, it was decided to provide heavier stone for this purpose and to place stones of about 2½ tons along the crest of the lowest berm, because it was found that the backwash of the waves at the lower level exerted a great force. It was further decided to grout with cement mortar the whole of the pitching on the sea face up to high water level.

(To be continued)

The New Graving Dock at Dundee

Approval of Design by Harbour Trust

At the latest meeting of the Dundee Harbour Trust plans were submitted for approval by Mr. Norman Matheson, General Manager and Engineer, showing the poroposed arrangement and dimensions of the new dry dock in accordance with the Board's previous instructions.

The plans were accompanied by a report in which it was stated that the proposed dimensions of the dry dock were as follows :—

Length inside dock at cope level	650-ft.
Length inside dock at floor level	645-ft.
Length over keel blocks	588-ft.
Width of dock entrance	85-ft.
Depth over keel blocks at h.w.o.s.t. ...	27-ft.
Clear width at cope level	112-ft.
Clear width at floor level	94-ft.

Mr. Matheson drew attention to his report of 1943 in which he stated that the dry dock should at least be capable of taking a vessel 600-ft. long with a width at entrance of not less than 80-ft.; and depth over blocks at h.w.o.s.t. 25-30-ft. The dimensions now suggested were generally in accordance with these previous figures, but is was considered essential to increase the entrance width to 85-ft. in order to meet the modern tendency towards increased beam of vessels—a ratio of beam to length of 1 to 7.5 being taken as the requirement which the proposed dry dock should meet. The depth of 27-ft. over keel blocks at h.w.o.s.t. might appear excessive, but it must be borne in mind that that figure was reduced to 22-ft. at neap tides, and thus anything less than the suggested depth would seriously impair the effectiveness of the dry dock.

The Proposed Site

Dealing with the site of the proposed dock, Mr. Matheson recalled that in the 1943 report he rejected the site at Stannergate as now proposed for two main reasons. First, the fact that once this area had been used the harbour had no further space for extension and, secondly, on account of its shape the area was not particularly suitable. The first objection was, of course, overcome if the general principle of development riverwards was found practicable and adopted in respect of future harbour extensions, and the new dry dock could quite well be placed in the Stannergate area without interferring with other development schemes. The second objection arose from the fact that the placing in this area of a dry dock having an entrance suitable for easy navigation meant the shutting off from direct access to the river of a considerable area of ground which might well be developed and occupied by firms requiring nearby wharfage for handling

New Graving Dock at Dundee—continued

their traffic. This objection had now been overcome by placing the dry dock at an angle which could still permit of access and yet provide a convenient line of approach for vessels using the dock. It was considered that material excavated in the construction of the dry dock would prove suitable for forming the necessary road embankment, and thus there would be a convenient means of disposing of much of the excavated material.

The proposed site, Mr. Matheson reported, held a number of advantages over that suggested in the 1943 report. Use of the latter site involved closing the Fish Dock and finding other accommodation for the vessels using that dock ; it also meant displacing a number of tenants, and considerable difficulty would undoubtedly arise in providing suitable alternative sites for these within the harbour area. The construction of berthage for fishing vessels and compensation to tenants would be a heavy addition to the cost of the proposed new dry dock. Similar difficulties did not arise with the site now suggested, since the area was largely undeveloped.

Proposed Jetty

On a river such as the Tay it was very necessary to provide some form of " lead-in " to a dry dock, with entrance direct from the river. Without this " lead-in " great difficulty was likely to be experienced in handling vessels in and out of the dock. It was therefore proposed to construct a jetty linking up at its outer end with the fitting-out wharf presently being constructed by the Caledon Shipbuilding and Engineering Company, Ltd. The jetty could be constructed with a continuous deck slab over the whole water area, or it might take the form of a series of dolphins extending from the dry dock entrance to the outer line of the fitting-out wharf. The proposed jetty, 500-ft. in length, should be ample for the size of vessel using the dry dock.

Certain dry docks had been so constructed that they could be used as berths for ordinary commercial purposes when not in use as dry docks, and the advisability of constructing a dry dock at Dundee in a similar fashion was worthy of consideration. Some adjustment in the normal design of the dock walls and in the closing caisson and pumping machinery were necessary to fulfil that requirement. Vertical piers (shown on a diagram submitted to the Trustees) were proposed as a form of construction allowing vessels to lie alongside the dry dock walls as at an ordinary quay wall.

Dealing with the time necessary for construction, and cost, Mr. Matheson stated that it would be appreciated that bills of quantities and prices could not be made up at this stage. But after consideration of the general features of the proposed work, and on the basis that the actual conditions met with were not greatly different from those assumed, he believed the dry dock and lead-in jetty, along with the river embankment extending eastwards from the dry dock entrance, and also the road diversion work, could be completed in a period of two years from the commencement of operations. The cost of the dry dock, lead-in jetty and river embankment would be approximately £620,000.

Committee's Recommendation

The Development Committee recommended that the site of the proposed dock as outlined be approved of, and that the general manager and engineer be authorised to proceed with the work of taking borings of the ground at the proposed site.

The Board approved the recommendation of the Development Committee and the chairman, **Mr. H. Giles Walker,** indicated that there would be a further report to the Board before any active constructional steps were taken. He imagined their first action, after getting information, would be to put in an application for a Government grant.

Port of London and the Home Guard.

The Port of London Authority have placed on record " their high appreciation of the efficiency and devotion to duty of Colonel Phillips and of the officers and their ranks who have served in the 14th, 15th and 24th Battalions of the (City of London) Home Guard, and of the services rendered to the Port generally by them."

Notable Port Personalities

XLVIII—Mr. Leslie Ford

Mr. Leslie E. Ford, M.Inst.T., on 1st January, 1945, succeeded Mr. W. J. Thomas as Chief Docks Manager of the Great Western Railway. As Chief Docks Manager, Mr. Ford is responsible for the administration of the Great Western Company's important docks at Cardiff, Swansea, Newport, Barry, Port Talbot, Penarth and Plymouth (Millbay), and has charge of the Company's fleet of passenger and cargo steamers.

Mr. Ford entered the Cardiff Divisional Superintendent's Office of the Great Western Railway in 1912. From 1914 to 1919 he served in the last war, first with the Welch Regiment, then with the 2nd Batt. Monmouthshire Regiment, to which he was commissioned in 1915.

Mr. LESLIE FORD

Mr. Ford held various posts from 1919 to 1921 in the Traffic Department, London Division, in the offices of the Superintendent of the Line and the District Goods Manager, Birmingham, and at stations in that district. He was included in the first quota of " Special Trainees " selected in the latter year.

In 1923 he was appointed Personal Clerk to Sir Felix Pole, the then General Manager, being transferred to the Docks Department in December of that year, and attached to the Chief Docks Manager's Office, in charge of the New Works Section. In 1926 Mr. Ford was promoted to be Outdoor Cargo Assistant to the Dock Manager, Cardiff, and in 1928 Assistant-in-Charge, Penarth Docks. He went to Swansea as Assistant Dock Manager in 1929, and was promoted Dock Manager, Port Talbot, in 1933. In 1938 he was appointed Dock Manager, Cardiff and Penarth Docks. This position he held only for a year before returning to the Chief Docks Manager's Office as Principal Assistant—subsequently re-styled Assistant Chief Docks Manager.

Mr. Ford is a Brunel Medallist (University of London), and holds the rank of Major in the Home Guard.

Melbourne Port Trade Returns.

Statistics of the trade of the port issued by the Melbourne Harbour Trust, show that cargo traffic in 1943 totalled 5,770,368 tons (3,809,329 tons imports and 1,961,039 tons exports), as compared with the 1942 figures of 6,787,695 tons (4,882,524 tons imports and 1,905,171 tons exports), and the 1938 figures of 6,449,209 tons (4,366,509 tons imports and 2,082,700 tons exports).

Notes of the Month

Dock Directorship Appointments.

Mr. W. McMinniagle, general manager, and Mr. J. W. Hair, secretary, have been appointed to the board of directors of the Middle Docks and Engineering Company, Ltd., South Shields.

Retirement of River Police Inspector.

Inspector Robert Tulley, of South Shields, will shortly retire after 36 years' service in the River Tyne Police. In his youth he served in sailing ships and steamers, and joined the River Police in 1909. He was made inspector in 1928.

Opening of New Turkish Port.

The new port works at Alexandretta, previously announced to be in course of construction, were brought into commission on January 10th. The works consist of a jetty, 500 yards long and 55 yards wide, with transit sheds, railway sidings, and quay cranes. Previously there was no quay berthage available for shipping.

Proposed New Peruvian Port.

The Peruvian Government has sanctioned a scheme for the construction of port works at Pisco, 264 kilometres South of Lima. Modern port terminal facilities are to be provided for the further development of important agriculture and mechanical activities in the Department of Ica and adjacent regions. The works will be financed partly by local dues and partly by a Government loan.

Malmö Port Extensions.

An expenditure of 4,800,000 kroner has been authorised by the City Council of Malmö, Sweden, to enable the Harbour Board to carry out a scheme of improvements. The Stockholm Quay in the Nyhamns Basin is to be enlarged by advancing the quayage line some 32 metres out into the Basin for a length of 330 metres. A four-storey warehouse is to be built and four cranes acquired.

Retirement of Former Dockmaster.

The Southern Railway Company has announced the retirement at the end of December of Captain F. Greenop, acting Divisional Marine Manager at Dover and Folkestone, and formerly Dockmaster at Dover. Captain Greenop had considerable war service, particularly during the previous war, in piloting vessels in and out of Dover and Folkestone harbours. In 1935 he was decorated by the King of the Belgians.

Reopening of Greenock Pier.

Princes Pier, Greenock, has been reopened after being closed for some years. This has been made necessary by a block on the Greenock railway line through a landslide, causing Gourock and stations west of Greenock Central to be isolated as far as rail traffic is concerned. Although efforts are being made to hasten repairs, it is likely that the work will take some considerable time. The Clyde steamers are now using the pier once more.

Hull Dock Appointments.

The London and North Eastern Railway announce the following appointments:—Mr. C. Corps, Dock Superintendent, Eastern Docks, Hull, has been appointed Assistant District Superintendent, Hull; Mr. G. B. Milsom, Dock Superintendent, Western Docks, Hull, has been appointed Dock Superintendent, Eastern Docks, Hull, and; Mr. A. V. Upton, Assistant Dock Superintendent, Eastern Docks, Hull, has been appointed Dock Superintendent, Western Docks, Hull.

Clyde Estuary Port Amalgamation.

Following the example of Greenock Harbour Trust and Greenock Chamber of Commerce, the Corporation of Greenock in a memorial to the Cooper Committee has expressed itself in favour of the setting up of one single authority to administer the harbours and ports in the Clyde area. The memorial states that, if the plans of the Local Harbour Trust were carried out, Greenock would become one of the finest harbour and dock undertakings in the country.

Durban Harbour Development.

Reclamation work is to be undertaken at the Port of Durban, Natal, and a contract for the job has been assigned to a Netherlands Company—the Hollandsch Aannemings Maatschappij.

Death of Docks Director.

The death has been announced at the age of 74 of Mr. J. H. Edwards, J.P., chairman and managing director of the Middle Docks and Engineering Company, Ltd., South Shields.

Death of Pilotage Superintendent.

Mr. William Stanley Holland, pilot superintendent of the Boston and Spalding Pilotage Authority, Lincolnshire, has died at the age of 74.

Proposed Improvements at Cork Harbour.

In connection with a scheme of improvements in the accommodation for shipping on the River Lee, estimated to cost £410,000, the Cork Harbour Commissioners are promoting a private Bill in the Dail empowering them to borrow sums up to £175,000.

Extensions at Port of Bonavista.

There has recently been completed at the Port of Bonavista, Newfoundland, two breakwaters, forming an inner harbour, connected with the outer harbour by a channel 200-ft. wide, with a minimum depth of 40-ft. A jetty for small boat passenger traffic is in course of construction.

Enlargement of Syrian Port.

Latakia, the principal seaport of Syria, is scheduled for enlargement at an estimated cost of £6,000,000. The execution of the important programme of works is expected to take three years to complete. Since the cession of Alexandretta to Turkey in 1939, Latakia is the only sea outlet of Syria.

Port Development on Black Sea.

Among Russian ports to undergo improvement and development after the war are Odessa and Touapsé. The former is to be restored to a new condition of efficiency having regard to the future development of its trade. It is anticipated that by 1947, it will have a cargo turn-over equal to that of its busiest years before the war. At Touapsé, on the north-eastern shore of the Black Sea, a first-class harbour is to be formed, capable of accommodating ships of the largest size. Novorossiisk and Ismail ports are also to be improved.

Proposed Development at Port Adelaide.

An important scheme of post-war construction at Port Adelaide, in the State of South Australia, has been laid before the Prime Minister of Australia. Estimated to cost in its entirety a sum of £902,000, the programme includes the construction of a large graving dock, the extension of existing wharves and reclamation of land, with a considerable amount of dredging. The scheme is endorsed by business interests at the port, including the Chamber of Commerce and the Chamber of Manufactures. It is suggested that a proportion of the cost should be borne by the Federal Government.

Lerwick Harbour Proposals.

Preliminary and tentative proposals for the development, after the war, of Lerwick Harbour in the Shetland Islands, have been laid before the Lerwick Harbour Trust. Introducing the proposals, Mr. R. J. H. Ganson, Convener of the County of Zetland, explained that the docking area would be six times that of the existing small boat harbour. Inside there would be accommodation for about 50 boats of approximately 60 feet of keel, and this would still leave plenty of room for boats entering or leaving the harbour. A rough estimate of the cost was £75,000. The generalities of the scheme met with all-round approval at the meeting, which agreed to leave the matter over until the opinions of fishermen and the local pilot could be obtained.

The "Spending Beach"

Its Influence on Wave Action

By "HELIOS."

Wave Behaviour at the Shore Line

The behaviour of waves on arriving at a shore is only well defined in one instance, viz.: when the shore is a vertical rigid wall with great depth of water alongside. The wave is then fully reflected and, for an indefinitely long train of uniform waves, with their resulting series of "standing" waves, the forces and motions are pretty well understood. In practical cases, the effect of the actual variations in the height, length and frontal breadth of the incident waves causes some ambiguity, but there is not very much doubt as to the general effect.

Matters are quite different on a sloping shore and become very complex if the slope is not uniform or when the beach material is mobile. In order to take the problem in its most simple form let us consider the case of a rigid uniform slope of indefinite extent reaching from a submerged depth of more than say one wave length and rising out of the water to such a height that no wave ever overtops the shore end of it, and assume that there is an indefinitely long series of incoming waves of uniform height and length. If the slope is one of 90°, the case is exactly that of the vertical wall which fully reflects the wave, as described above. If the slope is zero, there is no "beach" and the waves pass without interruption. These are the two extremes, full reflection and no reflection.

If the slope is 1 in 1 (45°) or steeper, the wave is almost fully reflected, but there are phase differences which complicate the form of the resulting combined waves.

If the slope is slightly less than 1 in 1, the progress of the foot of the incoming wave is checked relatively to that of the head and the face of the wave begins to develop a steep front. There is still considerable reflection and resultant "choppiness."

With slopes flatter than 1 in 2, this steep front generally "breaks," and the degree of reflection diminishes rather rapidly with the angle of slope.

With a slope of 1 in 5 the reflection is small and for a slope of 1 in 10 it is almost negligible.

If the slope is rough or permeable and/or mobile, reflection diminishes more rapidly with the angle, so that "spending" or "killing" beaches or "wave traps" vary in slope from say 1 in 2 down to say 1 in 20, according to the smoothness, impermeability and immobility.

Form of Breaking Wave

The exact form of the breaking wave is not predictable, but considerable information as to its cyclic change is obtainable from the observation of waves on shores or in model tanks, and such observation can be greatly elaborated by vertical, oblique or lateral photography or, better still, by cine-photos. Close-up views can be got by surf boats or bathers and the piling up of beaches during storms will also provide data.

There are, however, two difficulties. In nature the incoming wave is never quite regular in height, length or even in direction and if there is any reflection at all there can thus never be a steady regime of the combined waves. Furthermore, the waves are inconveniently long and large for measurement in the few seconds of their local existence. A hollow groyne, square to the wave front, with a stream-lined head and glass side walls would really be necessary to see what is really happening.

Secondly, in tank models the generated wave is never quite the same as a natural wind-produced wave and, if there is any reflection, after quite a short time the reflection reacts on the generator and the resultant wave is very complex, and becomes increasingly so, with the result that the tank is soon full of very irregularly disturbed water. The distorted waves behave erratically on the beach, and their reflections create new complexities and so on. The result is that a permanent regime is very hard to establish and, even if it is produced by careful synchronisation of the generated wave with its reflection, such regime is of an artificial character, and is not representative of natural sea conditions. Only in the case of zero reflection can stability be hoped for, and some experimenters confine their studies to the results obtained from solitary waves or short trains of waves. Here again the difficulty is to know how far one is justified in neglecting the effects which the tails of preceding waves would have had on the solitary wave, or whether the growth and decay of a short series of waves does not greatly modify the effects of the mid-members of the train.

Mathematicians frankly admit their inability to tackle the breaker problem from mechanical principles, principally because of the "rotation" and friction factors, so that the only course for the engineer is to combine the data obtained from shore and tank observations and use good judgment as to what may happen in certain postulated marine conditions, casting an eye occasionally on the mathematical theory of waves in general.

Hydrodynamic Analysis

There are three methods of analysis customary in hydrodynamics. That which is easiest to understand, but the most difficult to develop, is the Lagrangian system in which the actual motions of specific units of the water are followed, or, in other words, one studies the trajectories described by particles (e.g., in purely oscillatory waves of small height, the particles describe ellipses in shallow water and circles in deep water waves).

The second is the Eulerian method which fixes attention on a small region of space fixed with regard to the sea bed and considers how the water flows through it. Thus in an oscillatory wave the water passes backwards and forwards at varying angles across an imaginary fixed plane and the water surface rises and falls on that plane. This may be termed the "Transit" system.

A third system is to go with the form of the wave. Thus in a regular wave train, by the imaginary super-position of a velocity equal and opposite to that of the wave form, the whole is mentally converted into a steady stream through a stationary wave form which may be studied as such and be reconverted in detail by removing the imaginary velocity.

In "irrotational" flow, in which all the changes of form of the water are simple shear distortions, without angular momentum, the second system leads to remarkable results, closely simulating the behaviour of actual water, but when the conditions are incompatible with the absence of angular momentum and when friction is not negligible, only very general approximations are possible.

Continuity of flow and dynamic balance are in all cases determining conditions and certain general mechanical principles must obtain. Thus the rules of the conservation of energy and the conservation of angular momentum and the practical facts that "rotational" flow or "spin" cannot be reconverted to "irrotational" flow and that turbulent ("rotational") friction varies as the square of the contact velocity may all be invoked.

Process of "Spending"

With uniform trains of waves on a regular rigid shore the whole process of "spending" must be regularly periodic, the trajectories of the particles must be closed circuits, however long and complex they may be; the shoreward flux of water must be balanced by a seaward flux. Each wave in the train must pass through the same devolution so that the whole set must represent, as it were cinematographically, the degeneration of each of its constituent waves.

Great care is necessary to distinguish the advance of the "form" of the wave from that of the water in it. At the crests the water is advancing shorewards. Under the crests in the shallows the water is also advancing, but at the foot of the crests (in what would be the troughs of ordinary waves) the water is receding seawards. The shoreward velocities of the water are greater than the seaward velocities, but cannot last so long in each cycle. The trajectories are very long, and floating or suspended bodies may be carried shorewards in a series of jerks. The larger heavy bodies which may be disturbed tend to move shoreward because the shoreward velocities which can move them are greater than the seaward velocities which may not be able to move them. Thus during storms large pebbles and even masses of rock are taken shoreward, while the smaller pebbles and sand are carried outwards into the less disturbed water. Between storms the large

The "Spending Beach"—continued

pebbles remain undisturbed, but coarse sand is brought in by the smaller waves. There is thus a perpetual process of sorting going. Wheeler and Cornish describe these phenomena well in their books on the sea coast and waves.

A certain limited guidance to expression of the facts may be obtained from energy considerations. The total energy per foot of front of the free deep water wave of assumedly sine profile is

$$8\, h^2 l$$

foot pounds per wave length (h = height from crest to trough, l = length, crest to crest, both in feet).

Of this energy half is potential and half kinetic. Since all the particles are moving in circular trajectories at uniform speed, the kinetic energy is constant, but the potential energy moves shoreward at the same speed as the wave form. This is stated in the hydrodynamic texts as if the whole energy moved shorewards with half the wave velocity. The period of oscillation is

$$\sqrt{l/5.125} \text{ seconds}$$

so that the shoreward flux of energy, or **power,** is

$4\, h^2 l/\sqrt{l/5.125}$ = say $9\, h^2 \sqrt{l}$ foot pounds per second or, say, $h^2 \sqrt{l}/60$ horse-power.

Thus a 10-ft. wave, 144-ft. long, carries about 20 horse-power on every foot of frontage.

If there is no reflection, this stream of potential energy must be wholly consumed on the beach in producing eddies by impact, bed friction and counterflow, or in lifting material up to a higher level. Disregarding the lifting of beach material, which can only happen on a mobile beach, this consumption of energy may be represented in two alternate forms:

(a) as kinetic energy, or spin of rotating water masses carried in the wave ; and

(b) turbulent friction on the bed in which the spin is distributed into smaller and smaller packets until it finally becomes molecular motion, i.e., heat, which again is lost by radiation and conduction.

At any stage in the history of one wave, whatever has not been converted to spin, remains as potential (i.e., wave form) or kinetic energy of translation. If in the whole process the potential is not converted into its entirety, the balance returns seaward as potential and deforms the incoming wave. With complete reflection (full " clapotis ") the energy of the standing waves is alternately wholly potential and wholly kinetic, and the shoreward flux of potential is entirely annulled.

Reverting to the production of " spin," a cylindrical mass of water in " solid " rotation, whose diameter is D and whose peripheral velocity is v has a kinetic energy per unit front $4\, M/v^2$.

The mass M is $\frac{\pi w}{4} \frac{D^2}{g}$ per unit front or say $1.5\, D^2$ so that the kinetic energy is about $\frac{3}{8}\, D^2 v^2$ foot pounds. (w = 64 lbs. per cubic foot).

Thus, if $D = h_1$ and $v = \sqrt{2gh_1}$

the kinetic energy of the maximum 'solid' roll is $24\, h^3{}_1$ foot pounds as compared with say $3\, h_1{}^2\, l_1$ foot pounds for the potential energy per wave length of the sharply crested wave just before breaking. The potential energy of the free sine wave at sea is $4\, h^2\, l$, but the length decreases, the height increases, and the crests sharpen as the wave enters shallow water until l_1 is about equal to $7\, h_1$ and the potential energy is thus about $3\, h^2{}_1\, l_1$.

If l = say $15\, h$ and $l_1 = 7\, h_1$ and if it is assumed that the potential energy per wave length is constant before breaking $3\, h^2{}_1\, l_1 = 4\, h^2\, l$; $21\, h^3{}_1 = 60\, h^3$ and $h_1 = \sqrt[3]{60/21}\,.\,h$ or say $1.4\, h$.

Since $24\, h_1{}^3$ exceeds $21\, h^3{}_1$ it is clear that the " roll " does not need to be quite " solid " to take up all the potential energy of one wave length, or in other words, if the process of breaking is such that the potential energy is wholly converted into kinetic energy of rotation, a hollow cylinder the same height as the wave is capable of performing the transformation.

In actual fact, matters are not so simple. With a " full " break the top of the crest comes forward in a flat jet with a velocity which may be as much as twice the velocity of the wave form and tends to form as it descends such a hollow cylinder, but as the jet crashes on to the trough of the wave ahead of it, it splits partly into a forward jet with translatory motion and partly backward; the latter part only serves to produce a true " roll."

The water in the roll, as a foaming and spinning mass, is carried forward on the front of the now diminished crest of the broken wave. So far as that crest is still above the still water level, it yet has potential energy and therefore the energy of the " roll " must be less than that of the total potential energy of the original wave. The top of this smaller wave proceeds shoreward as a " shallow water " translatory wave and soon meets the returning and subsiding flank of its predecessor. This may form a second partial break, or rather a " bore " effect, with an incorporated " roll " of smaller dimensions in which some more of the remaining potential energy is converted to irrecoverable rotation. This process continues until the " roll " disappears at the water's edge at a level which depends on the kinetic energy of translation which has been developed by the forward fraction of the breaker jets.

This is a general sketch of the process as the writer sees it, and he hopes that further investigation, based firmly on observation and experiment, will enable empirical rules to be found for it, even if the complete hydrodynamic theory may be unattainable.

Review

Merchantmen at War: The official story of the Merchant Navy, 1939-1944. Pp. 142. Profusely illustrated. Price 1s. 9d. net. Prepared for the Ministry of War Transport by the Ministry of Information. London, 1945: H.M. Stationery Office.

The most casual reader in turning over the pages of this interesting and attractive publication could not fail to be struck with admiration for the heroism and devotion to duty recorded in its pages. If he happened to be of British nationality, he would, in addition, be stirred by a feeling of gratitude and pride towards the seamen of his race who had so gloriously maintained the tradition and honour of the country. It is, indeed, a magnificent record. A list of its contents gives but a feeble and imperfect account of its range and purport. There are three main divisions, comprising 18 sections dealing with every phase of the struggle carried on, in spite of difficulty and danger and death, by the brave men and lads of the mercantile marine, whose duty and responsibility it was to maintain the service of the seas, which they have done successfully and efficiently during the whole period of hostilities.

As instancing not merely the value of this service, but its absolute necessity, the Foreword states:

" Our merchantmen bring us at least one-third (in weight) of our food, including most of our meat, butter, cheese and wheat. Nor could our farmers raise their crops without the aid of fertilisers from overseas. As for our raw materials, the swiftest glance at them shows how our life is built on the sea: steel and timber from North America, wool from Australia and New Zealand, nitrates from South America, iron ore from Spain and West Africa, cotton from North and South America, Egypt and India, zinc and lead from North America and Australia, oil from America and Persia." Then it goes on to show how the merchant fleets of Britain have aided the war effort by transporting troops, convoying supplies and carrying stores ; so, in a thousand ways demonstrating the value of their assistance.

We cannot, of course, attempt to recite in detail all the acts of heroism to be found in the pages of the publication. Our readers are advised to get the volume for themselves and to peruse it carefully. It is not merely a matter of interest; it is a duty owed to those who have served the country so well.

Two short poems by the Poet Laureate are included, and there are five maps and a cargo diagram. The volume is clearly printed and excellently produced. Its only defect is lack of an Index, which would have been serviceable.

Waterfront Bases for Aircraft

*The Design and Planning of Airfields and Airports**

By BRIAN H. COLQUHOUN, B.Sc., M.Inst.C.E., M.I.Struct.E.
(Lately Director General of Aircraft Production Factories)

I WILL open this paper on one of the most controversial points of future civil aviation, namely, whether the seaplane will in the future come into its own again. It will be appreciated that this is a subject creating considerable argument and which affects most seriously any consideration concerned with the design and layout of future airports. Most members present here to-day will know that there are many people concerned with the operation of civilian flying in this country who state that the future of civilian flying lies in landplanes and that the seaplane is largely finished. Some American opinion does not agree with this but feels that for the first five years after the war the landplane will predominate because of the extensive development which it has had during the war period, and that after this five-year period the seaplane will again come into its own. The larger it becomes the more technical advantages it appears to possess.

These advantages have already on a number of occasions been pointed out by Mr. A. Gouge, who last year was President of the Royal Aeronautical Society and is one of the world's greatest authorities on seaplane design.

This same view on the future of seaplanes was also held to a certain extent by Sir Roy Fedden in his Cantor Lecture to the Royal Society of Arts on the 24th April, 1944, when he suggested it would be desirable for the Government to sponsor a flying boat now.

The Americans have already done this, and in fact they are now producing a flying boat of a size considerably larger than any other flying machine in existence to-day. Many of the disadvantages of the present type of flying boats, such as stepped hulls for take-off and poor aerodynamic profiles could be overcome by retractable fairings to the steps in the larger sizes. Large twin-hull flying boats of similar design in principle to the American Lightning Fighter, obviating the necessity for wing-tip floats, might easily come into their own. A machine of this type has been recently designed in mock-up form for Scottish Aviation.

On trans-oceanic routes it has been stressed by those who know the seaplane best that the seaplane would be safer and that it could be designed in the larger sizes as efficiently, if not more efficiently, than a landplane with its complicated retractable landing gear. Whilst it is admitted that the stress design of the hull for impact loadings increases the weight, as would retractable fairings which would have to be installed if the fuselage was to be as efficient and streamlined as the landplane, the net extra loadings involved are probably not as great on a seaplane as on a landplane with its heavy retractable landing gear, and the differences largely disappear when the size of aircraft become very large. Furthermore, if a very large flying machine is forced to crash land, and no suitable runways are available, it cannot use its undercarriage gear, so that safer crash landings have been effected on land in seaplanes than in landplanes.

Facilities for landing seaplanes on the trans-oceanic routes are generally more easily provided than for landplanes. It is quite conceivable that landplanes will require runways up to, say, 5 miles long, and it is well known that in many parts of the world this would prove extremely difficult from the civil engineering angle, if the air bases are to serve the big cities and ports with reasonable access. Quite apart from the question of the actual runways themselves, are the general approaches which are just as important. It is somewhat rare to find suitable flat country for the purpose without obstructions adjoining ports and towns.

Let me deal first with the portion of the Airport which many people in this country will say is of little or no interest, namely, the seaplane base. If we are considering airports for long distance travel and the seaplane is going to take any part in this, then I believe that this base must be in close proximity to the major landplane base in order that passengers and freight arriving by one form of aircraft may proceed on their journey to other parts of the world by the other form without great disadvantage. The distance between the two must, however, not be so close as to interfere with flying control. This assumption being correct, we are therefore limited, as far as the British Isles are concerned, in the position of major airports both for landplanes and seaplanes, and there is little doubt that the number of suitable sites for combined airports of this sort are limited to what one can perhaps count on one hand.

The seaplane base can be a natural base which requires only a small amount of construction work to fit it for this purpose, or what is more likely in so far as these Isles are concerned, it must be a base constructed near the mouth of a river, such as the Thames, Southampton Water, Severn, Ribble, Dee, Mersey, Clyde, Humber or Tyne, or some other similar place. Not all of these are by any means suitable and there may be other places around the British Isles which might be suitable for seaplane landings which are not necessarily on the mouths of rivers such, for instance, as Ayr Bay, adjacent to the existing aerodrome of Prestwick, where special claims are made for post-war possibilities in regard to both a landplane and seaplane airport.

Where it is intended to build a seaplane base at the mouth of a river, unless low-lying land of the right variety can be found, probably of a clay consistency, it will almost certainly be necessary that the base shall consist of a large and long wall or bank suitable for enclosing a lagoon of, say, at least 4 miles diameter which will have a depth of some 15-ft. The construction problem, therefore, devolves itself into the construction of an enclosing wall, and the evacuation of the material enclosed by that wall to such an extent that water can be increased to a depth of 15-ft. to accommodate suitable seaplane landings. In addition will be required the necessary buildings for loading and unloading passengers and materials, the gear at present under contemplation and necessary for controlling seaplanes at these points, and a large number of other items which will require most careful and detailed study. Although there are places in this country which have been used and are being used for seaplane traffic they are all, as far as I am aware, natural waterways such as Poole Harbour. At Poole, seaplanes are moving on the water in very close proximity to shipping lanes and while this is being done with reasonable success at the present time it must be remembered that the control of all aircraft and shipping in not only that region but in every other similar location is, during the war, rigorously controlled by the Government. In addition I feel that it is reasonable to assume that seaplane traffic, as I have previously said, will increase very considerably after the end of the war. If this view is the correct one it would seem to be advisable that waterways for seaplane use should be isolated from shipping lanes. It may, of course, be possible to determine these waterways by means of marking with buoys and although this would appear to be a simple solution it should be remembered that some means will have to be found in open waterways of this type to ensure, either by breakwaters or by other means, that the surface of the water is sufficiently undisturbed by weather or other conditions so as to ensure safe ingress and egress of seaplane traffic.

Where a lagoon has to be constructed to contain the seaplane base there will be two main items of civil engineering construction, on the enclosing wall, and the other the problem of dredging out the enclosed material. In the construction of the wall, the design of which will obviously vary according to the location and geo-

*Excerpts by permission from Paper read before the Institution of Structural Engineers, 23rd November, 1944.

Waterfront Bases for Aircraft—continued

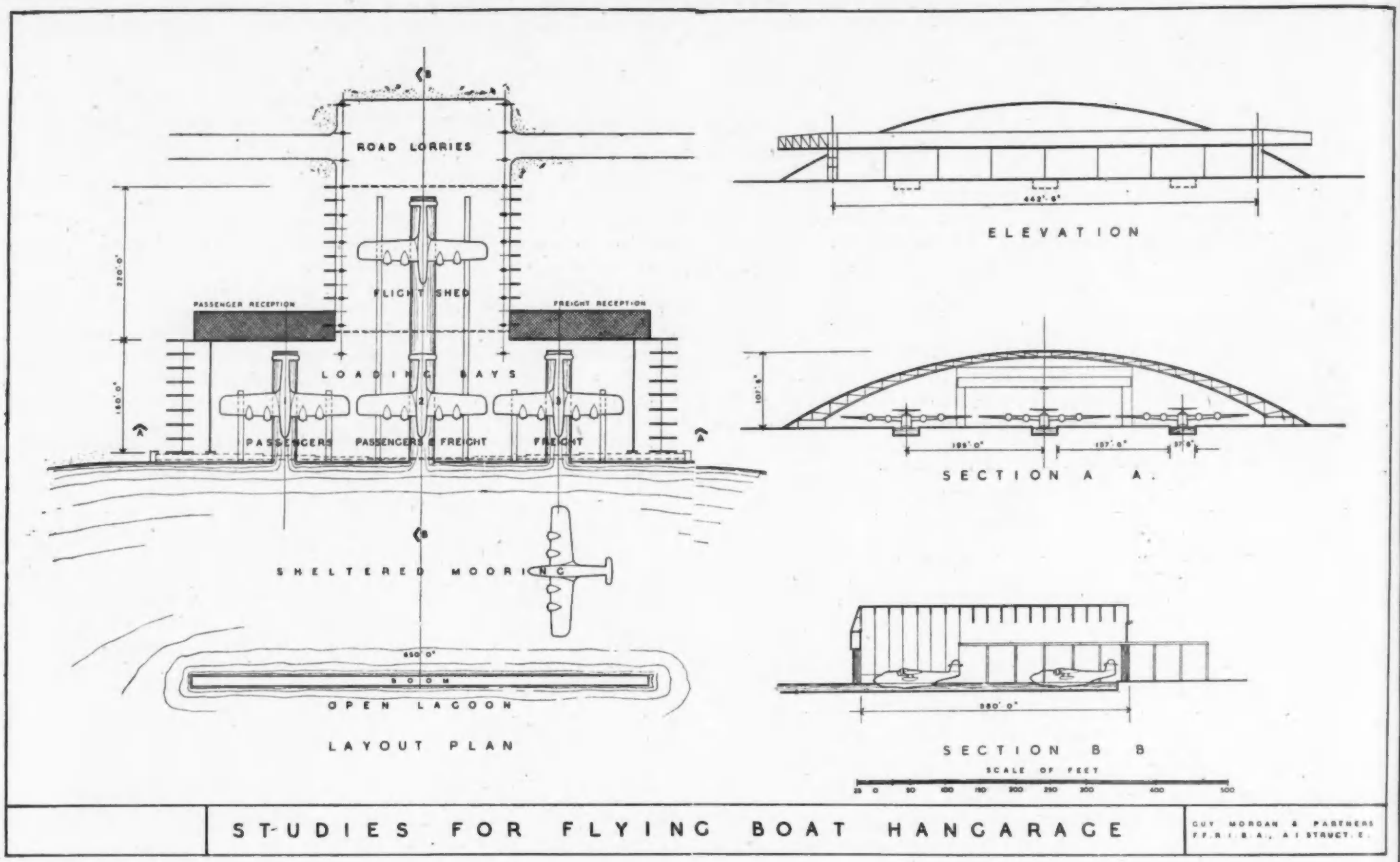


Illustration No. 1.

logical conditions of the area, arrangements must be made for sluice gates and to enable the lagoon to be kept at a more or less constant level with a gradual change of water by the rise and fall of the tides. If a lagoon is to be of a diameter of, say, 4 miles—and it is recommended that nothing less than this should be considered for a major airport—and has to be entirely enclosed by a wall, the wall will be over 12½ miles long. It is, therefore, a matter of major construction, the cost of which will be considerably affected by economical but adequate design. Again the question of dredging out the enclosed material is one which will require careful thought. On the assumption that the full 15-ft. will have to be removed, simple calculation shows that there will be nearly 200,000,000 cubic yards of material to be dredged. It is clear, therefore, that this again is going to be an item of considerable cost well worthy of careful investigation with a view to the best method of executing the work. Figures of these dimensions might well warrant the design and manufacture of special dredging plant, even if the life of the plant were limited to one job. It is worthy of mention here that even with these large figures the cost of a seaplan lagoon (assuming reasonably suitable conditions) would be considerably less than the cost of three runways and taxi tracks built to accommodate similar land craft.

The question of seaplane hangar accommodation is also one which has hitherto received little or no consideration and this is a question which in the very near future will be of high importance as the method of emplaning and disemplaning by means of tender is far too slow and cumbersome for air transport conditions of the future. I consider, therefore, that seaplanes must be either towed or otherwise propelled into moorages within hangar buildings either on shore or connected by jetty to the mainland in order to ensure that both passengers and freight can be disemplaned and conveyed to their destination without either loss of time or diminution of comfort.

During recent years I have had a considerable interest in all forms of air transport, and I have rarely seen at a seaplane base at any time during that period, or indeed before, any hangar accommodation designed specifically for the use of seaplanes. This then is clearly a subject which must be given careful and detailed thought and study. Reference to Illustration No. 1 will broadly indicate the result of few studies in providing this most necessary accommodation.

As I have said earlier, existing methods of conveying passengers to and from seaplanes is a most clumsy and awkward one and one which does not in any way help to attract the public to use seaplane transport. Also, as seaplanes lend themselves more readily than landplanes to the conveyance of freight, a quick and efficient method of loading and unloading freight conveyed by seaplane must be found. This can be done efficiently by conveying the seaplane in the quickest possible time to suitably designed hangarage from which access is available both to the landplane base and other forms of transport. There are, of course, many ways in which large seaplanes can be brought to their moorings with speed and safety. As far as I am aware none of these have yet been fully designed and developed in detail and I leave the problem with you for consideration, as no doubt many members of the engineering profession will be called upon to design work of this sort in the future and may have their own methods of satisfying this point.

At a later stage in this paper I propose to illustrate and describe to you certain schemes already designed and in existence, and which will perhaps elucidate still further the point which I am endeavouring to make. But from what I have said you will see

Waterfront Bases for Aircraft—continued

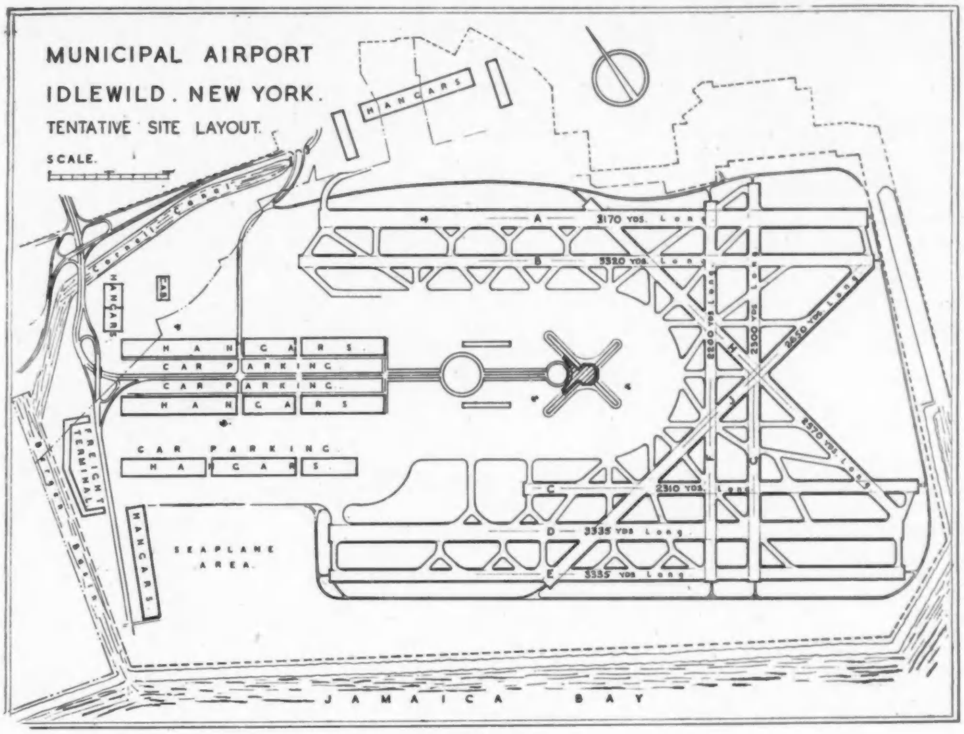


Illustration No. 2.

that there are many problems involved in the construction of a seaplane base which will have to be studied and solved in the near future by anyone who is concerned with this form of construction.

* * * * *

Examples of Seaplane Bases

I will now refer to three specific instances, namely, those of the Idlewild Airport near New York, which is now under construction, the Cliffe Airport, which has been designed as a suggestion for London's air terminal, and the proposed new Blackpool Airport.

Referring to Idlewild, it will be noted from illustration No. 2 that this airfield has been located on Jamaica Bay and within a few miles of the City of New York. It will thus be seen that the Americans place a great deal of importance upon the selection of a site for an air terminal of this kind being very close to a centre of dense population. This bears out the view which I have stated earlier in my paper. It is interesting also to note that in order to achieve two purposes (a) to obtain a large area of flat ground and, (b) to provide accommodation for seaplanes, on which clearly the Americans place considerable importance, it was decided to sheetpile a considerable area of Jamaica Bay and backfill with sand, this in itself being a vast and costly undertaking.

Although the design of this airfield is interesting, it will be noted that the Americans have only allowed for their longest runway to be 10,000-ft. in length, and it would appear that room for expansion is somewhat limited. There is also a very considerable school of thought which deprecates the location of the airport terminal buildings in the centre of the airfield, as it is thought by many pilots and control officers that the location of such buildings, which must of necessity be of considerable height, presents an unwelcome and perhaps unnecessary obstacle to safe flying in bad weather conditions.

Turning now to the Cliffe project, this airport was designed by Messrs. Guy Morgan & Partners, FF.R.I.B.A., for Mr. F. G. Miles, of Phillips & Powis Aircraft, Ltd. (now Miles Aircraft, Ltd.), and I feel that it is particularly worthy of consideration in this paper as at the time when it was designed in 1942 it was the most ambitious and comprehensive scheme produced for a major air terminal in this country. You will also see from Illustration No. 3 that provision has been made for a large seaplane lagoon immediately adjacent to the landing ground.

Although I do not propose to dwell on the details of the Cliffe scheme, as these have appeared in both the technical and daily press on many occasions, it should be noted that more than twelve months before any guidance was given by the authorities in the matter of lengths and widths of runways this scheme comprised runways of 2½ miles in length and 200 yards in width, with room for expansion if required. Further, a study of the proposed location of this airport will show that the land adjacent for this scheme is almost ideally sited for this purpose in that there are practically no buildings on the proposed site and the land is almost ideal from a topographical point of view. Turning to the meteorological aspect, it is frequently thought that the Thames Estuary within which this proposal is located is usually fogbound, or at any rate fogbound for a considerable period of the year. A close study of the meteorological data over the last thirty years indicates that this view is not correct, and in fact the site which has been recommended for this scheme is one which takes a high place amongst other sites in this country, considered meteorologically.

TABLE II

Nature of Subgrade	Combined thickness of base and surfacing for the following static undercarriage loads— 10.000 lb.	20.000 lb.	40,000 lb.	80,000 lb.
	inches	inches	inches	inches
Good Gravel, well graded ...	4-5	4-6	5-8	7-10
Sand, fairly clean	5-8	6-11	8-15	10-18
Gravel with Clay, poorly graded	5-11	6-14	8-18	10-25
Sand-Clay, well graded... ...	4-7	6.9	7-12	9-16
Sand-Clay, poorly graded ...	7-11	9-14	12-18	16-25
Sandy Clay, low plasticity ...	11-14	14-18	18-25	23-35
Silty Clay, medium plasticity...	12-17	16-24	22-33	28-44
Highly-plastic Clays	16-21	21-28	28-38	40.54

All the foregoing types of construction are classed as flexible and depend for their load bearing capacity on compressive and shear resisting qualities. As will be seen from Table II, wheel loads only approaching those anticipated in the future require very great thicknesses of graded or treated material. With such thicknesses it would be a very difficult matter to ensure a uniform result. Consequently, with the heavier types of aircraft at present in use rigid pavements constructed of concrete have been found to give the most reliable, all seasons, all weather form of construction. Such pavements, if properly constructed, have the capacity of carrying loads over soft spots and of spreading them on the ground below with thicknesses from one-quarter to one-third of that required with flexible pavements.

The homogeneous nature of concrete, however, causes it to be affected by temperature changes. These set up stresses in the material in direct proportion to the temperature range and also the area of slab or pavement. Similar stresses are set up by the shrinkage which takes place during the hardening and maturing period following the initial placing of the concrete. These stresses reduce the strength available for load carrying purposes so that to keep this at a maximum, precautions have to be taken to keep

Waterfront Bases for Aircraft—continued

temperature and shrinkage stresses within reasonable limits. This is achieved by dividing the pavement into comparatively small areas by means of expansion and other joints and by providing means whereby the pavement can slide on its sub-base. Expansion joints themselves create problems, the principal ones being (a) keeping adjoining slabs in line (b) differences in level due to "curling" during hot weather, and (c) transmitting load from one slab to another.

The majority of runways so far constructed have not been reinforced, the flexural strength of the concrete itself being relied on. It has been found, however, that to keep temperature stresses and joint spacing within practical limits, the thickness of concrete should not exceed 12-in. This means that for the loads from aircraft now being envisaged the additional load capacity has to be obtained by increasing the thickness of the sub-base or by reinforcing the concrete. By using reinforced concrete the problem of expansion jointing is simplified and the effects of thermal movement minimised.

The main objection raised against the use of reinforcement is that, with the use of modern concreting plant the accurate placing of steel is rendered difficult and uncertain. Experience of reinforcement in pavements to date, however, has been confined to comparatively lightweight steel and mesh fabric. With the use of quantities of steel in proportion to concrete of the same order as is used for concrete structures this objection would no longer hold good.

I feel, therefore, that for loads exceeding **50,000** lbs. per undercarriage, reinforced concrete should be used on a good and well-prepared sub-base. The better the latter, the lighter can be the reinforced concrete and in each individual case a judicious and economical combination of the two should be found.

Having arrived at this conclusion, we must consider the various factors affecting the design and cost of a pavement in relation to any particular aircraft load. They are considerably tied up with the design of aircraft which may use the airport, and are as follows:

(a) Bearing capacity of subsoil.
(b) Number of undercarriages.
(c) Tyre pressure.
(d) Undercarriage spacing.
(e) Wheel spacing.
(f) Impact loading.

(a) Bearing capacity of soil.

Having regard to the larger areas of pavement which will be required on future airfields, considerable variation in nature of the sub-soil is to be expected. This will necessitate a similar variation in the detailed design and strength of the pavements. To enable this to be done in a manner which will result in overall economy and uniformity and reliability of service, designs should be based on very comprehensive site tests. These should include:

(i) The collection and analysis of soil samples taken systematically from all over the site and at varying depths below the surface.
(ii) Pressure tests on various parts of the site, using a range of loads and bearing areas.
(iii) Experiments to ascertain treatment required to render the sub-grade reasonably uniform.

(b) Number of undercarriages.

For any given aircraft weight the load transmitted to the pavement from each undercarriage varies in almost direct proportion to the number of main undercarriages. In what follows, the tail or nose wheel has been neglected since the load it carries is small.

Careful study of Mr. Morgan's designs will also indicate that most careful consideration has been given to airport buildings in

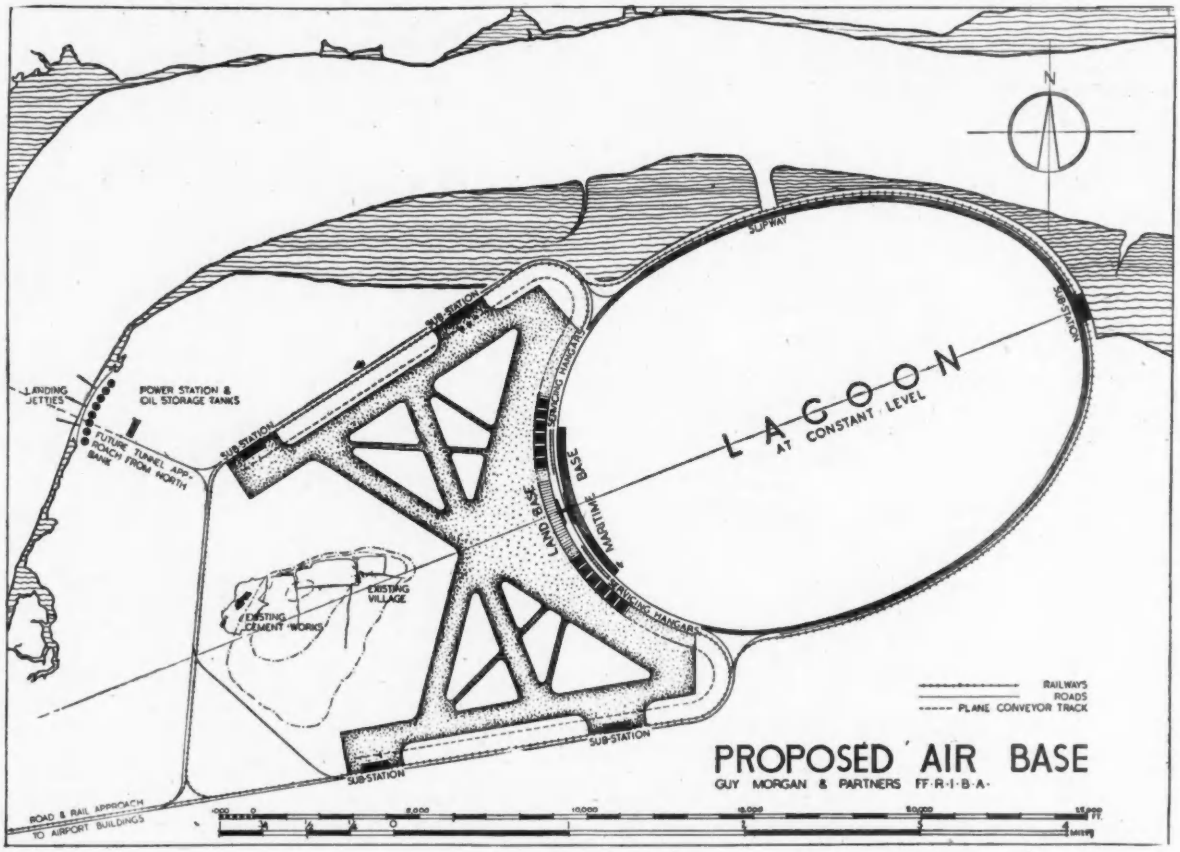


Illustration No. 3.

Waterfront Bases for Aircraft—continued

so much as seaplane and landplane hangars have been designed adequately to provide for contemplated air traffic conditions for the next decade.

I feel, in view of the date at which this scheme was prepared, and that there was very little information and data to draw from, considerable credit should be given to both Mr. Morgan and to his associates for this most worthy effort.

I have recently been fortunate enough to be consulted, together with Mr. Guy Morgan, by the Blackpool Corporation on a scheme for a proposed post-war trans-oceanic airport, details of which some of you have noticed recently in the press. I propose, therefore, to use this as my third illustration.

A plan of the proposal is shown in Illustration No. 4. The site selected conforms almost entirely and ideally with the various criteria and considerations discussed earlier in this paper. It will be seen that the full scheme includes a seaplane lagoon at the mouth of the River Ribble, connected to the land base by road and rail connections, partly in tunnel across the mouth of the River Ribble, to the airport buildings on the land base. Buildings will be provided as hangarage for repair, maintenance, storage and refuelling of seaplanes, also as terminal buildings for emplaning and disemplaning passengers and freight.

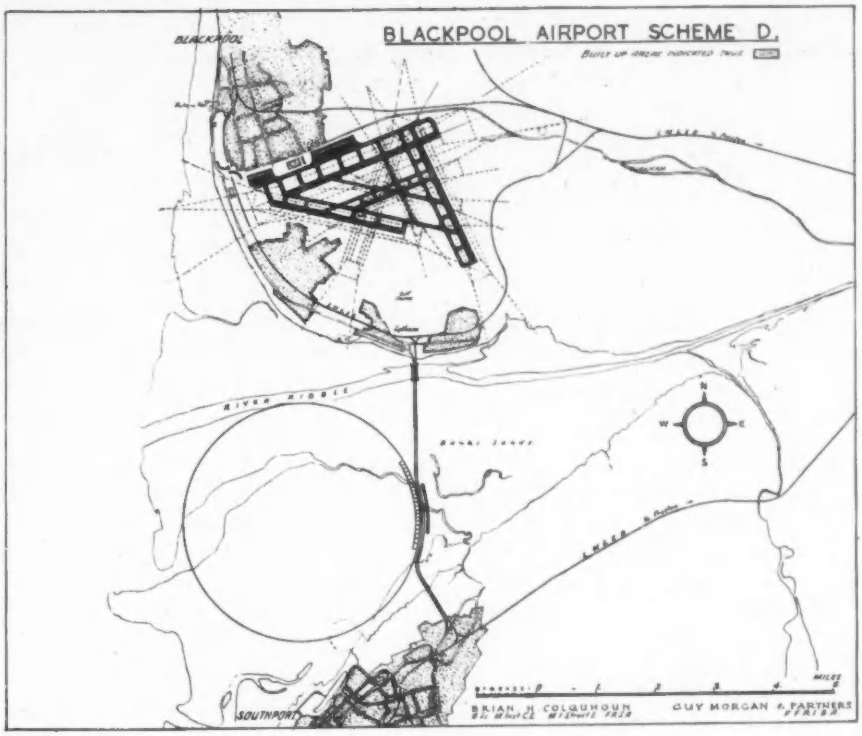


Illustration No. 4.

The land base itself will consist of three main runways, the principal of these being No. 1, 5,000 yds. long and 200 yds. wide in the direction of the prevailing wind. Two secondary runways, Nos. 2 and 4, are each 4,000 yds. long and 150 yds. wide, and will be placed in the other principal wind directions. All of these runways are capable of extension, in the case of No. 1 to a total length of 7,500 yds., and in the case of Nos. 2 and 3 to a total length of 6,500 yds. Provision has also been made for a fourth principal runway, should this ever be necessary. These three, or if necessary four, runways provide the main land base, but in addition to these, there has been planned to lie within the limits of the first three runways a subsidiary airport with runways parallel to the main runways and half-a-mile apart in each case. These subsidiary runways would be 2,750 yds. long and 66 yds. wide. This subsidiary airport within the major one will allow parallel landing to be carried out so that the main runways can be kept clear for large trans-oceanic aircraft arriving or departing without holding up smaller aircraft which can use the subsidiary airport. The layout of runways is shown on Illustration No. 4.

All the runways are connected by access tracks to perimeter tracks running round the airport to the main airport buildings and to the hangarage accommodation. Provision is made for hangars for repair, maintenance and storage of aircraft, some to be operated by the airport authorities and some capable of being let out to airline operators. Aircraft are enabled to travel between the airport buildings and hangarage without interfering with runways or the flying on the airport, and as far as possible taxi and perimeter tracks are arranged so that aircraft taxi-ing between the runways and the airport buildings will not interfere with the landing or taking off of aircraft

At the airport buildings provision is made for emplaning and disemplaning passengers and freight with the greatest speed and comfort, and designs have been prepared to allow within these buildings for customs and excise, transfer of passengers, luggage and freight to other aircraft, to storage and to other forms of transport.

In the terminal buildings, alongside the emplaning and disemplaning buildings, will be provided the airport offices, customs and excise, cloak rooms, waiting rooms, special reception rooms, restaurants and bars, exchange and information bureaux, shops and first-aid centres, and so on.

In addition to these, provision is made adjacent to the airport for the construction of an hotel and also for quarters for pilots and airport staff garages, car parks, 'bus parks and road and rail connections. The airport buildings, including the restaurants, bars and entertainment areas, will be designed and organised to accommodate visitors.

Mr. L. H. Bolton, Vice-Chairman of the Port of London Authority, has been nominated to represent the London District on the Executive Committee of the Dock and Harbour Authorities' Association.

American Association of Port Authorities.

At the Autumnal Convention of the American Association of Port Authorities held at New York in October last, Mr. R. T. Spengler, of Fort Lauderdale, Florida, was elected president in succession to Mr. Walter P. Hedden, of the Port of New York Authority. Other officers elected were as follows :

First vice-president, Mr. Arthur Eldridge of Los Angeles; second vice-president, Mr. E. O. Jewel of New Orleans; third vice-president, Mr. R. K. Smith of Ottawa, Canada, and secretary-treasurer, Mr. Tiley S. McChesney of New Orleans; directors, Mr. J. Spencer Smith of the New Jersey Board of Commerce and Navigation, and Mr. Walter G. Garland, Camden.

During the period of the Convention, Mr. Hedden presided as president, and other members of the Port Authority's staff, participated in panel discussions on various port matters and assisted in conducting tours of inspection and other courtesies to the visiting delegates. Total registration of the Convention was 235, including 16 from Canada, and 165 from parts of the United States outside of the port district.

Resolutions were passed to facilitate contacts between the ports and the Federal Government on disposal of surplus war property, to promote the revival of post-war coastwise and intercoastal shipping, to improve post-war trade statistics, to strengthen enforcement of regulations covering hazardous cargo, and to study the desirability of permitting manufacturing and exhibition in foreign trade zones.

Clyde Lighthouses Trust

Recommendations to Clyde Estuary Committee in regard to Unification of Port Administration

The following recommendations have been submitted to Lord Cooper's Committee on the proposed re-organisation of the Clyde Ports.

The Authority's views are limited to the navigational facilities which fall within its statutory powers as the Lights and Conservancy Authority within the area under its jurisdiction. It does not deal with docks or harbours.

(1) As regards its Lights duties, the Authority considers it will be of general advantage, *in any event*, if it remains in being as at present constituted as a separate body to deal with Lighthouses, Lights, Beacons, Buoys, Navigational Marks and other Aids to Navigation within the area under its jurisdiction, and that for the following reasons:—

(a) The Trust is closely allied to the Commissioners of Northern Lights, and is subject to the over-ruling control of that body in regard to Lights, Buoys and Navigational Aids.

(b) It is particularly equipped for this work. Its premises are centrally situated, and if any other body were to take over the work it would entail taking over its premises, plant and men and carrying it on exactly as it is carried on just now, without the experience acquired over 70 years.

(c) The records of the Trust show that it has kept itself abreast of all improvements in lights and navigational facilities. It has tested out all modern ideas and has adopted many of them. In addition, it has been pioneer in a number of navigational facilities, e.g., in the early days it was the first Authority in this country to adopt Lighted Buoys, and in recent years has developed wireless fog signalling and was, through its Engineers, the inventors of the Talking Beacon, which is of great use to navigation in fog.

(d) In view of the war-time developments of directional wireless, radar and other scientific devices, now largely secret, the adoption after the war by the Lights Authorities of some of the new navigational detective and directive facilities is considered as a probable future extension of the range of a Light Authority's duties. These may even extend to include the provision of air-beacons as an integral part of the Lights Service.

(e) At Port-Glasgow, the Trust has an efficient Workshop and Buoy Store and a Gas-making Plant. It owns a specially built vessel, the *Torch*, which is equipped for lifting and laying buoys and moorings, and is fitted with gas tanks and pumps to service the lighted buoys.

(f) The wages of the Lighthouse Keepers, their emoluments, pensions, etc., follow the National Scale.

(g) The Revenue of the Trust is derived entirely from the Light dues paid by Shipowners who shoulder the burden of Navigational Lights, and it therefore is equitable that these should be separately controlled.

(h) The Trustees appointed under the Statute are fully representative of all the interests in the Clyde.

For the foregoing, as well as on general grounds, there is an essential case for retaining the Clyde Lighthouses Trust as a separate Lights Authority to deal with the specialised problems of the Clyde approaches.

(2) As regards its Conservancy duties, the cost of which is provided out of income from the light dues, the Authority is of opinion that, if a Central Control is considered advisable, it would appear reasonable that the conservancy of the area under the Authority's jurisdiction should be under the one Control and the cost of dredging and maintenance a charge on that body with, however, the essential proviso that the safeguarding clauses in the Clyde Lighthouses Act providing against any diversion of the dredged Channel of the River Clyde prejudicial to the harbours, docks and industries of the Lower Reaches and the approaches to the Up River Docks and Port of Glasgow are embodied in the Constitution of any new Authority, and that provision is made for adequate representation of these interests.

Provided also that the Central Control undertakes an equitable proportion of the obligations of the Authority for the pensioning of their officials and higher paid servants on the same basis as the Authority would have undertaken if it had continued unaltered. The authority has not any Pension Scheme nor has it any Fund set apart for pensions. It is, however, paying at present a pension to a retired Treasurer, a retired Master of the S.S. *Torch*, a retired Lighthouse Keeper, and a retired Carpenter from the Works. It has been its custom, out of its funds, to make adequate provision for pensioning the officials, whether part or whole-time, and the members of its staff who, through age or illness, have retired."

Correspondence

To the Editor of "The Dock and Harbour Authority."

Dolphins.

Dear Sir,

I was particularly interested in the article entitled "Dolphins," by Mr. R. R. Minikin, which appears in your current issue (January, 1945).

Although perhaps in these days I am not able to follow in all its details Mr. Minikin's calculations, I appreciate his sincere attempt to equate the kinetic energy expended by the berthing ship to the work done in displacing the dolphin piles from a calculated point below river or sea bed level.

Having built, repaired, and assessed damages to a good many dolphins in tidal waters, I think I may fairly say I have some experience as to their behaviour, and in this respect I would not agree with a conclusion reached by the Author that "only on rare occasions does a navigated ship bump a dolphin or jetty in a direction such as to deliver the whole of the lateral energy to the point of collision . . . ."

I have found that most dolphin casualties of any magnitude which occur, do, in fact, result from this very cause. The ship, if the least out of her true berthing approach, hits the dolphin generally on the corner only and the disintegration of the structure is then progressive till the ship's movement is arrested or until the whole dolphin is destroyed.

In deep water dolphins, therefore, for which I have been responsible, the up and down stream corners have been most heavily buttressed in the later designs.

I am, Sir,
Yours faithfully,
ERNEST LATHAM, M.Inst.C.E.

72, Victoria Street,
Westminster S.W.1.
13th January, 1945.

To the Editor of "The Dock and Harbour Authority."

Slipway at Port Elizabeth

Dear Sir,

Referring to the paragraph (page 170 of your issue of December, 1944) regarding the construction of a Slipway at Port Elizabeth, South Africa, it may be of interest to state that the Slipway Appliances referred to were constructed to my design and specification. They are a development and improvement of those which were constructed to my Patent design for the ports of Grimsby, Hull, Fleetwood, Peterhead, Fraserburgh and Macduff and which were referred to in an illustrated article of your issue of December, 1929.

In the case of the Port Elizabeth Slipway, the appliances were further developed in so far that a telescopic cradle was also introduced, thereby enabling the appliances to deal with much longer vessels on the main slipway and smaller vessels on the side slipping appliances.

Yours faithfully,
ARCH. HENDERSON.
M.Inst.C.E.

21, Bridge Street,
Aberdeen.
15th December, 1944.

Free Port Area at Cadiz.

It is announced that a free port zone is to be established at the Port of Cadiz, for which the Spanish Government have assigned a credit of five million pesetas.

de

ole
ng
as
n-
it
nt
S.
om
ke
or
or

,,
ue

all
re
ng
a

ay
he
ot
on
in
to

de
p,
in
re
til

en
ost

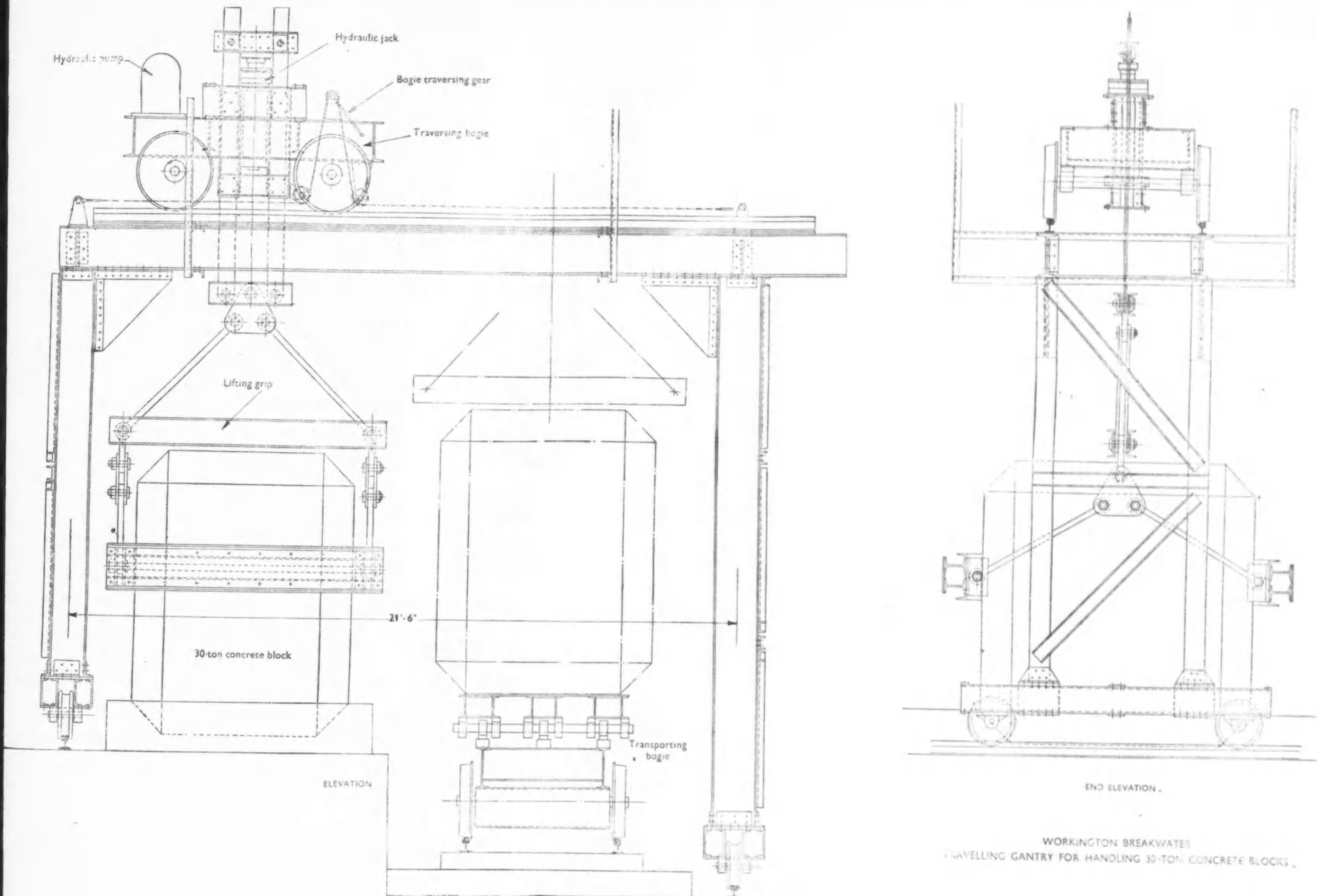
E.

er,
h,
ay
fi-
ch
y,
ch
er,

re
o-
ger
de

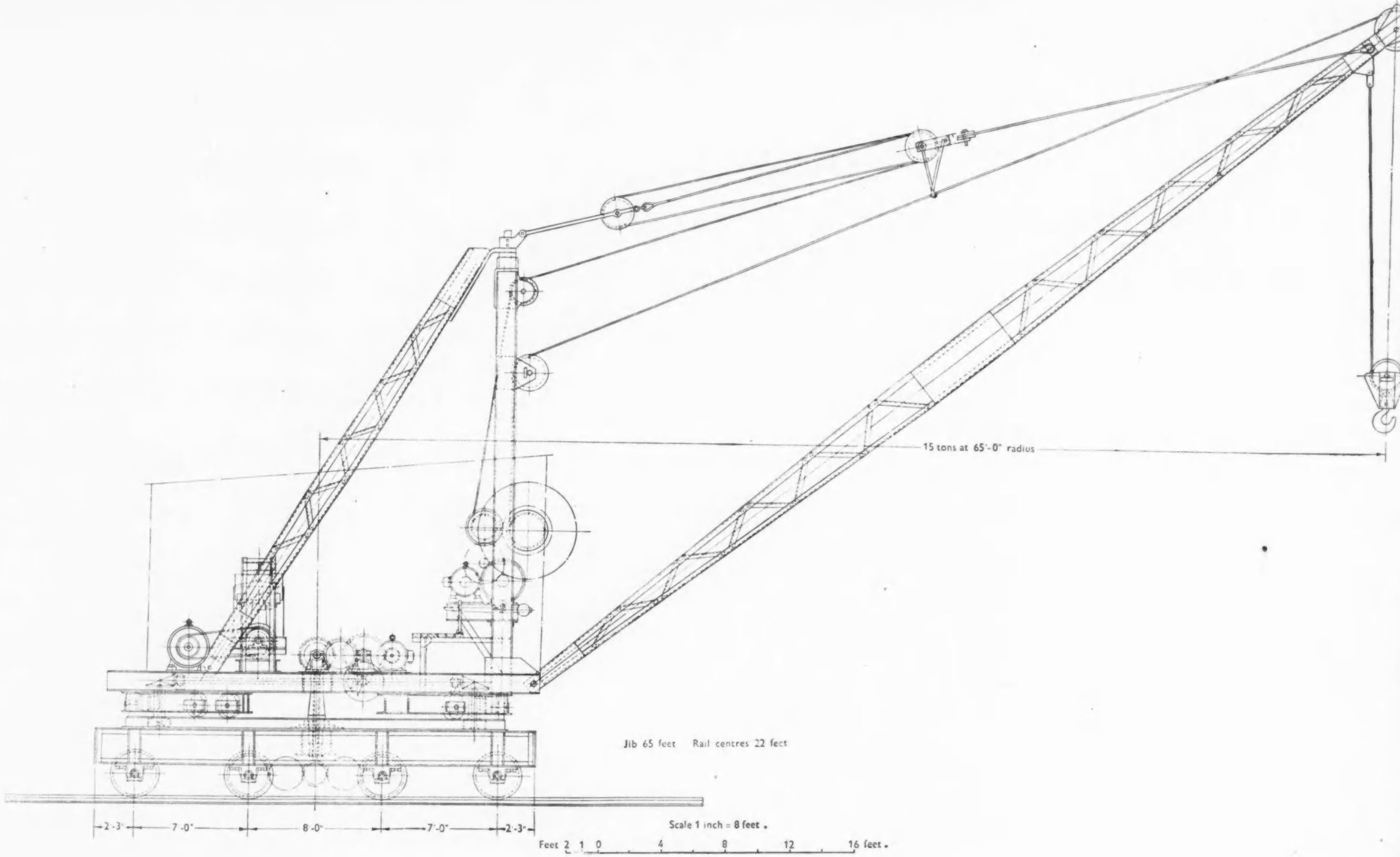
N.

at
as-



WORKINGTON BREAKWATER
TRAVELLING GANTRY FOR HANDLING 30-TON CONCRETE BLOCKS.

Fig. 7.



GENERAL ARRANGEMENT.

15-TON ELECTRIC UNIVERSAL CRANE

Fig. 8.

f

s
c
t
p
v
c
is
t
p
p
g
w
a
o
th
th
h
th
F
h
ca
w
fr
b
a
d
it
le
ca
p
fr
pi
d
si
m
si
or
of
In
ac
by
op
tr
w
co
bo
fa
a
pr
on
is
at
an
pi
th
pr

The Execution of Port Works

Machinery and Plant in Connection with Civil Engineering Construction*

By Sir GEORGE MOWLEM BURT, M.Inst.C.E.

(Concluded from page 205)

Plant Used in Pile-Driving

Pile-driving is one of the oldest engineering methods adopted for obtaining foundations, and was used by primitive man.

Although steam and other forms of power have increased the speed and efficiency with which pile-driving operations can be carried out, generally speaking, the principle employed is still the same as that employed in pre-historic times. In broad outline, piling plant consists of an upright guide on which some form of weight can be raised and dropped so that the weight falls on a definite point each time it is dropped. The pile frame of to-day is generally a steel structure of broad base, 12-16 feet square, with two guides or leaders spaced approximately 6 inches apart, held in position by raking frames. The hammer, or object which drives the pile, operates in front of, and is held in position by, two upright guides. The modern pile frame usually has four castor-type wheels which can be turned independently of the frame through any angle. On top of the base of the frame a turntable is placed on which the frame proper is built, so that the frame can be turned through an angle and drive piles not only in front, but also to the side and rear if necessary. Many pile frames of this type have also incorporated a screw jack arrangement which allows the frame to be battered back to allow piles to be driven on a rake. For driving piles in the foundations of buildings, etc., some special heavy frames have been built which consist of a large under-carriage moving on its own wheels, backwards, forwards, or sideways, and carrying a pile frame more or less like any other pile frame, which can also be moved in any direction and battered back to drive piles on a rake. This is a very heavy type of plant, and is suitable only where a great number of piles have to be driven, because the cost of transport and erection is very high; it has not been used to any large extent in Great Britain. Cantilever pile frames are constructed so that the pile frame proper can project out beyond the land, or piles already driven, to drive piles in the water ahead of the frame. In using a cantilever pile frame, very little temporary work is necessary, as the permanent piles carry the pile frame. With regard to the pile hammer, the drop hammer as used throughout the ages is still generally considered the best by most engineers, although many types of automatic and semi-automatic hammers are used for pile-driving. The single-acting semi-automatic hammer acts in the same way as an ordinary drop hammer, the driving force being purely the weight of the cylinder of the hammer, falling on the head of the pile. In this hammer the piston-rod is hollow and acts as a steam-pipe, admitting steam into the cylinder, whilst the steam is controlled by a valve arrangement attached to the top of the piston and operated by a rope. The length of stroke of the hammer is controlled by the length of time the valve is kept open by the operator working the rope. This type of hammer is useful in driving heavy concrete or timber piles, as by means of false leaders which are bolted on to the pile and act as a guide for the cylinder rising and falling, the hammer can be used to drive piles without the use of a pile frame. The false leaders are bolted on to the pile and project some 10-12 feet above the pile; the hammer is then placed on the pile with its cod fixed in between the leaders, the steam-hose is attached to the hammer, and thus a man, by operating the rope attached to the valve, can do the actual driving of the pile without any crane or other lifting gear being attached to the hammer or pile. The double-acting steam-hammer depends not only upon the weight of the hammer for giving the blow, but also upon the pressure of steam, the valve arrangement in the hammer being such that steam lifts the hammer a fraction, and then, entering the hammer from another part, forces the hammer down on the anvil-block. The actual lift of the hammer is only a fraction of an inch, and the efficiency of driving is dependent upon the steam, and upon the number of blows delivered per minute; in other words, a double acting hammer delivers a large number of light blows in comparision with a few heavy blows of the semi-automatic or the drop monkey. For this reason the automatic hammer is not generally used for driving heavy reinforced-concrete piles, as the blow is not sufficient to overcome the inertia of the heavy pile; but it is of great use in driving steel joist piles or steel sheet-piles. The hammers can be operated by steam or compressed air, and many of them can be used for driving piles under water; this is achieved by having an exhaust pipe to carry the steam or compressed air to the surface. This type of hammer is very useful in cases of restricted headroom, or it can be hung on to the side of the pile to be driven.

Petrol-driven hammers which act in a similar way to the steam semi-automatic hammer have also been designed and used, whilst an electric hammer for light work has been designed on the principle of the solenoid, the weight of the hammer being lifted off the pile so that when the current is cut off the hammer will drop freely on to the piling. Steel sheet-piling of many types and shapes is now available to the engineer for harbour works, and besides extensive application for coffer-dams and other temporary works, it is being used to a greater extent for the construction of permanent work to form quays, locks, dock walls, etc. Generally, for permanent work, the practice is to have the piles made with a copper-content steel which helps to prevent rusting of the metal.

Cranes

In connection with harbour and dock works, cranes of all types and construction are used, driven by steam, electricity, diesel engines, petrol engines, compressed air, and hydraulic power. In general respects these cranes are similar to cranes used in all other types of work, but the very heavy cranes, of 40, 50, 60 tons, etc., are much more commonly used on this class of work than on any other. For constructing breakwaters, considerable use has been made of the " Titan " crane, the advantage of which is that no temporary works are required, as the crane builds the breakwater and travels out on the finished structure. An example of such a crane is the 40-ton " Titan," originally built for the construction of Fishguard harbour. This crane has a maximum radius of 125 feet and a range of traversing on the racking motion of 97 feet. It is driven by a steam engine with two cylinders of 11 inches bore and 18 inches stroke, with hydraulic brakes, and two cylinders of 10 inches bore and 12 inches stroke. A 40-ton load is lifted on eight parts of 3¾-inch circumference rope. Another type of crane very commonly used in the construction of breakwaters is the " Goliath " crane. Practically the whole of the harbour works at Dover were built with 40-ton cranes of this type, which, however, when used in harbour work for the construction of breakwaters, etc., require a stage on each side of the permanent work to carry the crane. Cranes of this type with capacities of 42 tons and 60 tons were also used by Messrs. S. Pearson & Sons on the construction of the harbour at Dover. Fig. 7, shows a " Goliath " crane made by the Author's firm, for handling 30-ton concrete blocks. This is a hydraulic crane of very simple construction, made from steel joists and channels from the firm's stock. The main lifting gear is an hydraulic ram, actuated by a small electrically-driven hydraulic pump; the bogey is traversed across the " Goliath " by means of hand-operated chain reduction gears, as also is the travelling of the crane longitudinally on its rail.

*Excerpt from Paper read before the Institution of Civil Engineers on 14th March, 1944, and reprinted by permission.

The Execution of Port Works—continued

Scotch Derricks

Are also used considerably in harbour works, as the long reach of the jib over the water is found to be very advantageous. These cranes are commonly made in sizes of up to 25 tons capacity, with jibs up to 150 feet long; but larger ones are also made, an example of which is that used recently in building a breakwater at Valparaiso; this was an electrically driven block-setting derrick lifting 62 tons at 60 feet radius.

A crane now in use, very similar to the Scotch derrick, is the "Universal" crane, which is fitted with two diagonal back stays, the stays, mast, and jib revolving on the travelling carriage in a complete circle. This is a very useful type of crane for setting blocks on harbour construction. Details are as follows: 15-ton electric; jib 65 feet; rail-centres 22 feet; the carriage of the crane has eight wheels, and the crane can handle a 15-ton load at 65 feet from the centre of rotation. These cranes can be equipped with steam, electric or diesel electric drive (Fig. 8).

Overhead Cableways

The overhead cableway has been largely used on bridge building and dam construction. A cableway consists of two towers with a main cable which carries a load spanning between them, on which a carriage, usually three-wheeled, is pulled backwards and forwards by a second cable called a "travelling rope." Below the carriage is suspended a hoisting pulley, and a third rope, called the "hosting rope," runs over this pulley and round a hoisting block. When the carriage is being travelled outwards or inwards, the hoisting rope and the travelling rope must travel at the same speed so that the rope remains at a constant level with regard to the main cable. A fourth rope, called the "button" rope, which is just above the main cable, is used in order to ensure that the carriage is stopped at the desirable position. Cableways are frequently made to travel laterally so that they can cover all positions on the work. A development of the overhead cableway, which has been used very frequently during recent years, is the tower scraper. This is a similar arrangement to the cableway, but instead of carrying a load, it is designed to haul a scraper bucket which scrapes the ground up below the cableway; the bucket is then hoisted and travels back towards the tower end of the cableway where the material scraped can be dropped into a heap or into hoppers for removal from the site.

Pneumatic Breakwater

The pneumatic breakwater has been found to be very advantageous in reducing wave action, where divers are employed. It consists of a pipe lying on the bottom of the sea, or supported near the bottom, with small holes about a ¼ inch diameter drilled at intervals of 4-6 inches. When compressed air is pumped into this pipe the resulting bubbles of air coming out of the perforations break up the waves and make diving work possible where it would often have to be suspended on account of weather. This type of wave breaker was used during the construction of the Dover Train-Ferry dock with considerably success, although, unfortunately, not until the job was practically complete.

Port of Liverpool

Programme of Future Developments

In an article contributed to the *Liverpool Post* of January 8th, **Mr. R. J. Hodges,** General Manager and Secretary of the Mersey Docks and Harbour Board, outlines the Board's future policy in regard to the development of the port. He enumerates the steps to be taken under the following four heads :

(a) The general re-equipment of the Board's estate, which is necessary after the heavy demands made upon it during the war years ;

(b) Welfare arrangements ;

(c) The constant improvement and replacing of their mechanical cargo handling appliances, the number of which has been greatly extended in recent years, the acquirement and application of new devices being under the most constant survey ;

(d) The re-equipment of their graving docks ; and

(e) The improvement of facilities for accommodating oil tankers.

Road and Rail Access

He then continues as follows :

"In conjunction with the Dock Access Committee set up by the Minister of War Transport, the Board are investigating and planning the road and rail access to their estate. To this end, which is so much linked up with the general post-war planning of Merseyside, they are most anxious to maintain as complete a liaison as possible with the local authorities in whose areas the port lies, and it is only by this means that the needs of the citizens of Merseyside can be aligned with the needs of the docks on which those citizens depend for their living.

"It is naturally vital to the successful administration of the Port of Liverpool as a whole that both sides of the Dock Estate should share in the traffic obtaining. For geographical reasons this is sometimes difficult to attain, and it is therefore felt that with a view to obtaining as far as possible financial equality a sound objective would be the freeing of the Mersey Tunnel from tolls.

Finance

He concludes his article with an admonition on the subject of financial outlay involved.

"All objects of improvement," he points out, "involve the same fundamental factor—cost. In seeking to make the port as modern and well equipped as it is possible to be the Board have to keep their natural inclinations in restraint. It is easy to embark on a lavish outlay of capital expenditure ; it is another thing to adjust income to meet the running charges on that expenditure. This fact is one which is sometimes overlooked by users of the port who are enthusiastic for the adoption of one scheme or another, but forget what their reaction to an increase in port charges would be.

"Summing up, those responsible for the management of the port are doing their utmost so to plan that their scheme will fit into whatever form the post-war trade of the world may emerge. It is for the users of the port—shipowner and trader, employer and employed—to do their part by co-operation and broad outlook to maintain Merseyside as the sea port of industrial England."

Port of Melbourne Improvements

The following works, scheduled as urgent, are to be undertaken by the Melbourne Harbour Trust as soon as the military and financial situations permit : the re-conditioning of berths at the Victoria Dock, the reconstruction of berths at the South Wharf, North Wharf Road and the Central pier at Victoria Dock, together with the construction and fitting-out of a new dredger and tug.

These works are described as essentially deferred maintenance jobs, renewals and replacements, and the estimated cost is £678,000. New Works, chargeable to capital, comprise : construction of No. 1 berth at Appleton Dock (£147,000) ; construction of two coal berths at Appleton Dock (£350,000) ; widening and deepening of the river channel (£250,000) ; reclamation of Stoney Creek Basin (£60,000) ; provision of six wharf cranes (£66,000) and extension of transit sheds at Victoria Dock (£22,000).

The new dredger will be employed in widening and deepening the River Yarra, which at present restricts the passage to vessels not exceeding 28-ft. draught. Approval has already been given to the lowering of the sewer conduit passing across the river bed at an estimated cost of £200,000.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this Journal should not be taken as an indication that they are necessarily available for export.

The Port of Antwerp

Condition after German Occupation

The remarkable escape of the Port of Antwerp from destruction by the German Army, lends interest to the following statement of the condition in which it fell into the hands of the Allies, recently contributed to *Lloyd's List* by their Special Correspondent.

" Only that part of Antwerp," he says, " dealing with inland traffic, with its great canal and river systems linking the port with Northern France, Alsace-Lorraine, the Rhineland, Westphalia and Central Europe, had been made use of by the enemy. At the same time, the Germans, probably with a view to the eventual use of the port when they had won the war, had kept the Scheldt fully dredged.

" A certain amount of damage was done to the two main locks, the Kruisschans Lock and the Royers Lock—the two key stones of the port—but this damage was relatively small and easily repaired. At the Kruisschans Lock, the outer (seaward) gate was found to be severely damaged, as was No. 2 gate (seaward end), No. 3 gate (south end) was undamaged, but No. 4 gate was damaged. A further attempt by the enemy, after Antwerp was in our possession, to damage the Kruisschans Lock failed, and all the damage to the gates was made good in time for the opening of the port at the end of November. At the Royers Lock, of the three caisson gates the outer (seaward) gate and the centre (spare) gate were in good order, but the inner gate had been damaged. This also was fully repaired and the lock overhauled before the port was opened.

" The entrance to Royers Lock was found to be badly silted, and there was a tremendous tonnage of sand and scrap metal fouling many of the berths. But a force of some 2,000 civilian labourers was engaged in clearance work and this was soon successfully completed. The Scheldt buoyage system was in a much better state than could have been expected, and no extensive repairs or replacements were necessary.

" Of the 24 floating pneumatic elevators, each with a capacity of between 200 and 300 tons an hour, 16 were in working condition and the remainder required only minor repairs. Of the cranes and hydraulic and electric hoisting apparatus (which number over 600 and comprise floating cranes of from three to 150 tons capacity, electric loading bridges of 15 tons and hoppers of 200 tons), more than 90 per cent. were in perfect working order.

" All the small dock tugs were intact, and the big river tugs, which managed to escape to this country in 1940, have now returned to the port. Outside the port many of the bridges had been blown and the rail tracks damaged, for that ground was the scene of heavy fighting, but in the port itself all the marshalling yards and clearing points were undamaged. There was at first a shortage of locomotives, but this has since been made good from this country. All the ship-repair yards and dry docks, together with their facilities, were in excellent condition, and these will be able to meet not only the needs of Antwerp but will relieve the pressure on British dry docks.

" When the port was liberated many ships were left alongside the quays and in the shipyards. These included two 10,000-ton cargo vessels, a 12,000-ton tanker and dozens of ships capable of carrying between 2,000 and 3,000 tons of cargo. Some of these had been sunk at their berths.

" The riverside quays, which stretch for nearly 3½ miles and represent one-seventh of the total mooring capacity of the port, together with their large number of open and closed sheds and the vast attendant railway system, were all left in working order, as also were the Albert, Lefebvre, Kattendijk and Hout Docks. These docks, together with the Leopold and Hansa Docks, provide ample berthage accommodation for all the ships using the port."

The Kruisschans Lock, it may be added, is the most modern and largest entrance to the great system of docks lying to the north of the port. It has a length of 885-ft., a width of 115-ft., and a depth of water over sills of 47-ft. at h.w.o.s.t. The Royers Lock, connected with the same dock system, but of earlier date of construction, is 590-ft. long, 72-ft. wide, and has a depth over sills of 37-ft.

British Canal Control

Deadlock on Question of Compensation

Negotiations between the Ministry of War Transport and the owners of British canals on the subject of financial compensation for control during the war period, which have been in progress for over twelve months, have failed to achieve agreement. Certain important canal owners, including the Grand Union Company, have rejected as inadequate the offers put forward by the Ministry. Broadly, the terms provided for the controlled undertakings to receive approximately the average of their earnings for the three years immediately preceding the outbreak of the war with adjustments in the light of special circumstances.

The Grand Union Canal Company put forward three exceptional circumstances necessitating a substantial upward adjustment, viz., (1) the much improved earnings of the company, (2) the considerable increase in the company's annual provision for maintenance and depreciation, and (3) the fact that the Grand Union Canal Carrying Company though separately controlled (and therefore, in the opinion of the Ministry, outside the scope of the proposed settlement) is a wholly-owned subsidiary. No proposals made by the Ministry were considered satisfactory and the matter has accordingly fallen through, so that, unlike the railways, the canals will take the financial risk of whatever chances there are in their favour, or against them, during the war period.